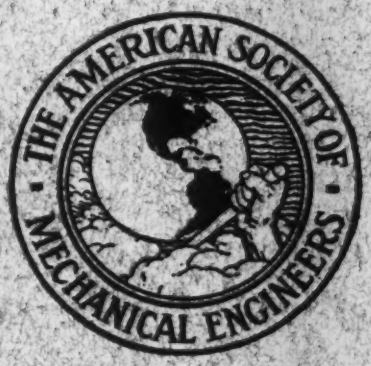
620.62
A51
M8

JUN 5 1915

Engineering Library

THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS



· JUNE · 1915 ·

SPRING MEETING, BUFFALO, JUNE 22-25

EXPANSION OF LOCAL SECTIONS

AT the Spring Meeting of the Society, a Conference of Delegates from the fourteen Local Sections of the Society will be held. The object of this Conference is to improve the conditions under which Local Sections are now operated and to arrange for the establishment of new Sections wherever the members of a locality evince sufficient interest.

This development is one of the most important activities now being undertaken by the Society and it is deserving of the support of every member. Those members residing in districts where sections are now established, are urged to coöperate with the Committee on Local Sections in making the meetings of increasing value and interest. Members in other localities are urged to unite in the establishment of new sections and to increase the membership of the Society in those centers, which as yet lack sufficient numbers to make possible successful meetings.

The Committee advocates the holding of joint meetings which will tend to widen the scope of the papers presented, and also give greater opportunity for increasing one's acquaintances among the profession.

The Spring Meeting offers members an opportunity to extend the courtesies of the Society to their friends and associates. The Secretary will be glad to extend an invitation to any person whose name and address is sent him.

Total Membership of the Society, May 21, 1915	*6289*
New Members since January 1, 1915	*185*

THE JOURNAL OF
THE AMERICAN SOCIETY OF
MECHANICAL ENGINEERS

Volume 37 June 1915 Number 6

THE SPRING MEETING

BUFFALO, JUNE 22 to 25

CITY HALL, BUFFALO

THE complete program of the Spring Meeting at Buffalo is published in this number and it is evident that there is not only an attractive group of papers, but that socially the meeting will afford a period of rare enjoyment to those who accept the hospitality of the Buffalo engineers.

Buffalo is not only a city whose industries have developed remarkably during the past few years and thus are of unusual interest to visiting engineers, but it is a city of beautiful avenues and parks and is always attractive to the visitor. Its proximity to Niagara Falls adds still further to the opportunities for pleasure during a stay in the city, and the Local Committee have perfected plans so that every one may enjoy to the utmost the attractions which Buffalo and its environs provide.

It will be noted from the program that there are three periods for professional sessions, on Wednesday, Thursday and Friday mornings, leaving the afternoons free for excursions.

On Tuesday evening there will be interesting addresses of welcome and response respectively by Mr. Frank B. Baird of Buffalo and Dr. John A. Brashear, President of the Society, and refreshments will be served by the local members of the Society and the members of the Engineering Society of Buffalo.

The day Wednesday will be spent at Niagara Falls, the party going there by special electric cars and holding its morning session in the auditorium of the Shredded Wheat Biscuit Company's factory. The return trip will be in time for dinner in Buffalo and an evening lecture by Dr. F. H. Newell, formerly Chief of the United States Reclamation Service, who will speak on the Engineer as a Citizen and illustrate his address with beautiful colored lantern slides.

On Thursday, besides various excursions, the ladies are to be entertained by an automobile trip, and tea is to be served by the Twentieth Century Woman's Club, to which both the members and the ladies are invited. In the evening there will be the reception and dance, when there will be an opportunity to meet socially many of the people in Buffalo.

It is expected that a delegation from Cleveland will come by boat and will be present during the day Thursday.

On Friday afternoon there will be still further opportunities offered for visits to points of engineering interest.

The arrangements for the meeting have been in the hands of the Meetings Committee, John H. Barr, Chairman, and several Buffalo committees, the chairmen of which are as follows: David Bell, General Committee; D. W. Sowers, Finance Committee; H. P. Parrock, Reception Committee; David C. Howard, Entertainment Committee; W. H. Carrier, Hotel Committee; John Younger, Printing and Publicity Committee; Mrs. William Henry Barr, Ladies Committee.

The time for the meeting is such that the commencement season of the colleges will be over, so that a large representation of college men is expected, and it is believed that the accessibility of Buffalo from sections of the country where a large percentage of the membership of the Society is located, will result in a large attendance. It is assured that every member who attends will feel well repaid and count the meeting as a time of great profit and pleasure.

PROGRAM OF THE SPRING MEETING

HEADQUARTERS AT HOTEL STATLER, JUNE 22 TO 25

Tuesday, June 22, Buffalo

2:00 p.m. Opening of headquarters and registration.
Mezzanine Floor

6:00 p.m. Conference and dinner of officers and representatives of local sections and the Local Sections Committee.

8:30 p.m. Informal reception and reunion.
Ball Room, Second Floor

An address of welcome will be made by Mr. Frank B. Baird, representing the industries of Buffalo, to which Dr. John A. Brashear, President of the Society, will respond. The evening will afford an opportunity for the reunion of members and their reception by the Buffalo engineers. Refreshments will be served.

Wednesday, June 23, Niagara Falls

9:00 a.m. The party will leave Hotel Statler by special trolley cars for Niagara Falls. Price for the round trip, including the Gorge Route, $1.25.

10:30 a.m. Business Meeting. Report of Tellers on Amendment to Constitution. Presentation from the Council of proposed amendments to C 53 and C 48 of the Constitution. Reports of professional committees.
Auditorium of The Shredded Wheat Co.'s Factory

PROFESSIONAL SESSION FOLLOWING BUSINESS MEETING

THE STUDY OF A SHAFT AND ITS IMPROVEMENT BY HEAT TREATMENT, John Younger

A COMPARISON OF THE PROPERTIES OF NICKEL, CARBON AND MANGANESE STEEL, Robert R. Abbott

USE OF CORRUGATED FURNACES FOR VERTICAL FIRE-TUBE BOILERS, F. W. Dean

ON MEASURING GAS WEIGHTS, Thos. E. Butterfield.

During the morning the ladies will have time at their disposal to visit the Shredded Wheat Company's factory and the plant of the Falls Chocolate Company, as well as to enjoy the outdoor surroundings of the Federal Reservation at the brink of the Falls.

1:00 p.m. Luncheon at the International Hotel, price 75 cents.

Wednesday Afternoon, Niagara Falls

2:30 p.m. Special cars will be provided for those who desire to take the Gorge Route trip, the price for which is included in the round-trip ticket from Buffalo. There will be an opportunity for those who do not take this trip to inspect the power plants both on the Canadian and American sides, or to enjoy the scenic beauties of Niagara Falls and Goat Island.

5:00 p.m. The special cars for Buffalo will leave the International Railway Station.

Wednesday Evening, Buffalo

8:30 p.m. Illustrated lecture on "The Engineer as a Citizen," by Dr. F. H. Newell, formerly Chief of the U. S. Reclamation Service.
Ball Room, Second Floor, Hotel Statler

Thursday, June 24, Buffalo

10:00 a.m. Simultaneous professional sessions.

PROFESSIONAL SESSION
Ball Room, Second Floor, Hotel Statler

RATIONAL DESIGN AND ANALYSIS OF HEAT TRANSFER APPARATUS, E. E. Wilson

INFLUENCE OF DISK FRICTION ON TURBINE PUMP DESIGN, F. zur Nedden

SURFACE CONDENSERS, C. F. Braun

SIMULTANEOUS SESSION
Assembly Room, Second Floor, Hotel Statler

SOME MECHANICAL FEATURES OF THE HYDRATION OF PORTLAND CEMENT AND THE MAKING OF CONCRETE AS REVEALED BY MICROSCOPIC STUDY, Nathan C. Johnson

DESIGN OF RECTANGULAR CONCRETE BEAMS, Howard Harding

MODEL EXPERIMENTS AND THE FORMS OF EMPIRICAL EQUATIONS, Edgar Buckingham

THE EFFECT OF RELATIVE HUMIDITY ON AN OAK TANNED LEATHER BELT, W. W. Bird and F. W. Roys

11:00 a.m. Automobile ride for the ladies through the city and its environs and the park system.

Thursday Afternoon, Buffalo

2:00 p.m. Council Meeting.
Assembly Room, Second Floor, Hotel Statler

2:00 p.m. Parties will leave the hotel to visit manufacturing plants and points of interest.

5:00 p.m. Tea will be served for the ladies and members by the Twentieth Century Woman's Club at their Club House, 495 Delaware Avenue.

Thursday Evening, Buffalo

9:00 p.m. Reception and dance.
Ball Room, Second Floor, Hotel Statler

This will be the leading social function of the Spring Meeting. It is expected that many residents of Buffalo will attend as well as their visiting friends. A collation will be served. Invitations will be sent to all who register at headquarters, which, to be valid, must be endorsed at the registration desk and for which there will be a charge of $2.50 per person.

Friday, June 25, Buffalo

10:00 a.m. Professional Session.
Ball Room, Second Floor, Hotel Statler

LAWS OF LUBRICATION OF JOURNAL BEARINGS, M. D. Hersey

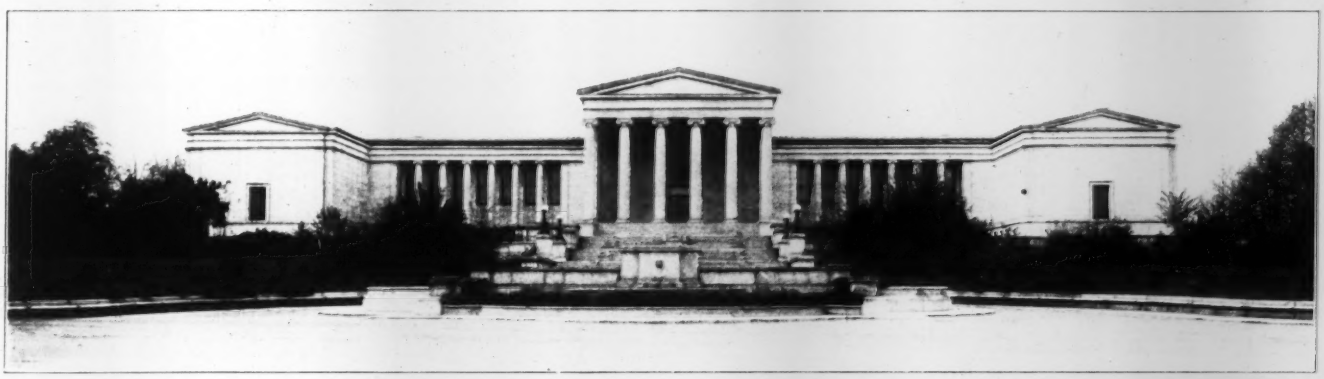
EXPENSE DISTRIBUTION, H. L. Gantt

LAPS AND LAPPING, W. A. Knight

This is the last session, but it is planned that any who desire may visit manufacturing plants during the afternoon and the Local Committee will be pleased to provide guides for this purpose.

PAPERS FOR THE SPRING MEETING

Brief abstracts of the papers for the Spring Meeting which had been assigned up to the time of going to press were printed in the last number of The Journal. In this issue the complete list of papers is given in the program and abstracts follow of those which were not listed in the May number. These papers are of a high order of merit and are miscellaneous in character, treating of a variety of subjects. All of these papers will be printed in pamphlet form for distribution in advance of the meeting and copies of any or all of them will be sent gratis to members applying *to the Secretary* prior to the meeting. Application should be made as soon as possible to insure delivery before the meeting. After the meeting extended abstracts of the papers and an account of the proceedings, with discussion, will appear in The Journal so that members will have early information concerning the events of the meeting. Finally, the papers, together with the discussion, will be printed in complete form in the annual volume of Transactions for 1915 for permanent reference.



ALBRIGHT ART GALLERY
ONE OF THE LARGEST AND MOST ATTRACTIVE IN THE UNITED STATES

HISTORICAL SOCIETY'S BUILDING

STONE ARCH BRIDGE

SCENES IN DELAWARE PARK, ONE OF BUFFALO'S BEAUTIFUL PARK CENTERS

A COMPARISON OF THE PROPERTIES OF NICKEL, CARBON AND MANGANESE STEEL

BY ROBERT H. ABBOTT

This paper gives a comparison of the physical properties, both in the annealed and heat-treated state, of three steels of the same carbon contents, the first of which is an ordinary carbon steel, the second a nickel steel, and the third a manganese steel containing 1.6 per cent manganese.

Test bars of each kind were quenched from slightly above the upper critical points and were then reheated, or drawn at varying temperatures from 300 deg. fahr. to 1300 deg. fahr. The results of these tests are given in the form of charts for comparison. The elastic limit, ma imum strength, reduction in area, elongation and Brinell hardness are compared. Equations are developed, giving these results in terms of the temperature of draw.

Tests were then made comparing the effects produced upon the physical properties by quenching from various temperatures above and below the upper critical points. These results are given in the form of charts.

CONCLUSIONS: In the three steels under comparison, it required three times as much nickel as it did of manganese to give the same increase in physical strength. In the un-

The Whole Day Wednesday, June 23, will be Spent at

heat-treated steels, the increase in strength was not accompanied by a decrease in toughness; rather the reverse. In the heat treated steels this increase in strength is accompanied by an increase in toughness, with the nickel steel, while with the manganese steel it is accompanied by a decrease in toughness.

ON MEASURING GAS WEIGHTS

By Thomas E. Butterfield

The author believes that gas quantities should be expressed in weight rather than in volume measure. Where the performance of different sets of apparatus for generating, burning, compressing or exhausting gas is to be justly compared, density must be determined. This makes it natural to express quantity as weight, volume measures also being given, but as of subordinate interest.

It is also suggested that where chemical analysis is used to determine the proportions of the various materials entering a combustion process, a method of computation be standardized which depends on the determination of the weights of each chemical element entering the reaction. An illustrative example is given.

ON THE LAWS OF LUBRICATION OF JOURNAL BEARINGS

By M. D. Hersey

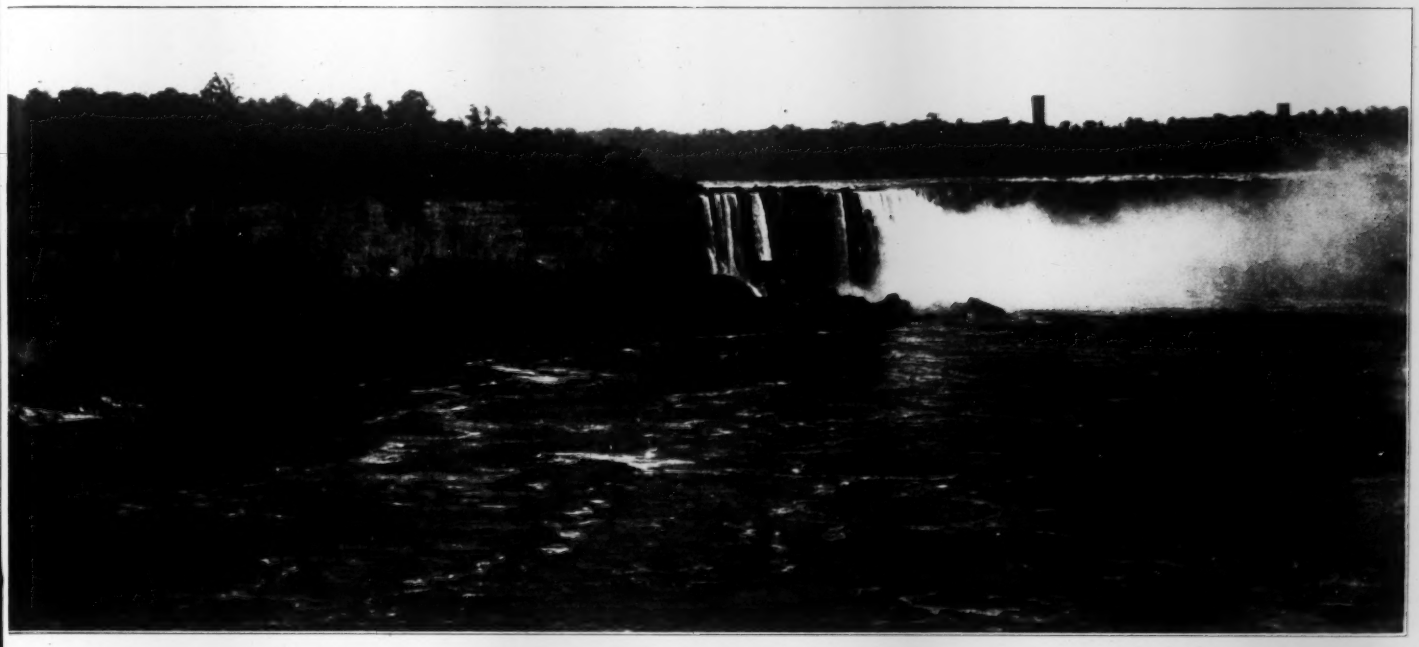
In order to establish a rational basis for bearing design, it would be desirable to have empirical equations, or curves, showing accurately and completely how the friction loss and load-carrying power of bearings depend on all the physical conditions governing the action of lubrication, including, of course, the size, shape, and fit of the bearing, the speed, degree of lubrication, properties of the lubricant, and characteristics of the cooling system. The problem of mapping out the laws of lubrication in this general way, whether by piecing together existing data or by making new experiments, is such a complicated one that it is worth while to stop and consider whether any general principles are available which may serve to simplify it.

A recognition of the above facts has led to the present paper, the object of which is first to reduce the problem to a physical basis by suitable definitions and restrictions, and then to develop certain general relations which will simplify the solution of the problem. These relations are of two sorts and may be summarized as follows:

a The general forms of the laws of lubrication are deduced by dimensional reasoning, and the characteristic properties of dynamically similar bearings are discussed in the paper.

b A distinction is pointed out between the "characteristic" i.e. purely dynamical equations, and the "working" equations needed in the final design of a bearing. It is then shown that the dynamical characteristics of the bearing, and the thermal characteristics of the lubricant and the cooling system are three independent parts of the problem which may be separately investigated, thus greatly diminishing the number of combinations of conditions needed for mapping out the laws of lubrication over the full range of all the variables involved. Finally a general method has been outlined for deducing the desired working equations by utilizing the results of these three investigations as shown.

The paper closes with an analysis of the "ideal bearing," i.e. one which is perfectly circular in cross section, etc. In this connection Sommerfeld's results are reproduced in a convenient form for practical use, and extended by a treatment of heating effects. While intended primarily as a particular illustration of the foregoing general relations, the equations and curves of the ideal bearing doubtless afford a first approximation to the laws of lubrication of actual bearings.



Niagara Falls Where the first Professional Session will be held

EXCURSIONS TO INDUSTRIAL PLANTS

On Thursday and Friday afternoons there will be no professional sessions at the Spring Meeting and parties will be made up to visit the various industrial plants of Buffalo and vicinity, cordial invitations from which have been received by the Local Committee. In the last number of The Journal accounts of several of these plants were published, with illustrations of some of them, and invitations have since been extended by several firms referred to below. The list of plants to be visited includes the following: The Lackawanna Steel Company; Buffalo Foundry and Machine Company; Larkin Company, the mail-order house; Wickwire Steel Company; Pratt and Lambert Company, varnish manufacturers; Snow Steam Pump Works; Pierce-Arrow Motor Car Company; Pratt and Letchworth Company, Bingham and Taylor Company, The Aluminum Castings Company, and the D. W. Sowers Manufacturing Company, all engaged in foundry work; the Buffalo Forge Company; the Simonds Manufacturing Company, manufacturer of saws; the Roycroft Shops, East Aurora; the power plants at Niagara Falls where are also the Shredded Wheat Biscuit Company, the Falls Chocolate Company and the large number of electro-chemical industries, which latter, however, for the most part are not open to the public. Besides these firms there are the four referred to below.

AMERICAN RADIATOR COMPANY

Buffalo manufactures more heating apparatus than any other city in the world. Here are located three large plants of the American Radiator Company, and also their Institute for Thermal Research. National advertising has made their heating systems well known to almost everyone.

THE J. P. DEVINE COMPANY

The J. P. Devine Company of Buffalo has specialized in the introduction and development of the use of the vacuum drying and impregnating apparatus in this country, and its installations are extensively used in the chemical and allied industries. By reason of its extended experience in supplying standard and special equipment to the chemical industries, and because of its German connections, this company has been able to develop special facilities in supplying autoclaves, digestors, nitrating and sulphonating kettles, rectifying columns, etc., used in the manufacture of benzol, aniline, touloul and other products that have been heretofore obtained from Europe. Members of the society will be accorded a cordial reception at this plant and will find there much that is of interest.

THE CROSBY COMPANY

Buffalo is also the home of The Crosby Company, makers of sheet metal stampings for a variety of purposes, including those used in automobiles, motor cycles, bicycles, cream separators, lawn mowers, etc. In addition, they design, build and install special machinery for producing difficult pieces of metal stamping. Their plant is exceptionally large and well equipped, and should be inspected by all visiting engineers.

GOULD COUPLER COMPANY

At Depew, just outside of Buffalo, is located the plant of the Gould Coupler Company, manufacturers of railway couplers, truck frames, general steel castings, electric train lighting systems and storage batteries. The plant is a large one, giving employment to some 3000 men, and embraces production work of unusually interesting character in a variety of different lines. A cordial invitation is extended to the visiting engineers to inspect their works and it is hoped that a large number may be able to take advantage of the opportunity.

HOTELS AND TRANSPORTATION

The hotels at Buffalo recommended by the Local Committee for guests attending the Spring Meeting, with rates, are as given below. Members should make reservations by writing direct to the hotel at which they desire to stay during the convention.

HOTEL STATLER, HEADQUARTERS FOR THE SPRING MEETING

Single room with bath, $2.50 to $4.50.
Single room with shower bath only, $2.00.
Double room with bath, $4.00 to $6.00.
Double room with shower bath only, $3.00 to $4.00.
Double room with tub and shower bath, $4.00 to $7.00.

HOTEL IROQUOIS

Single room with bath, $3.00 to $5.00.
Single room with shower bath only, $2.50 to $3.00.
Single room without bath, $2.00 to $3.00.
Double room with bath, $5.00 to $7.00.
Double room with shower bath only, $4.00 to $5.00.
Double room without bath, $3.00 to $4.00.

LAFAYETTE HOTEL

Single room with bath, $2.50 and upwards.
Single room with shower bath only, $2.00 and upwards.
Single room without bath, $1.50 and upwards.
Double room with bath, $4.00 and upwards.
Double room with shower bath only, $3.50 and upwards.
Double room without bath, $3.00 and upwards.

HOTEL LENOX

Single room with bath, $2.50.
Single room without bath, $1.50.
Double room with bath, $3.50.
Double room without bath, $2.50.

The Iroquois and Lafayette hotels are located near the Hotel Statler. The Hotel Lenox is a large family hotel pleasantly situated on North Street at Delaware Avenue, in the residential district. Visitors desiring to register at the latter should take a Miller Transfer Company's taxicab at the station and instruct the driver to charge the service to the hotel.

TRANSPORTATION

The present arrangements of the railroads with regard to transportation of those attending conventions are such that no material reduction can be secured, and no effort will be made by the Society to organize parties for the trip to and from Buffalo except as members going on a particular train may wish to leave their names at the Society headquarters for the benefit of others who may wish to travel on the same train. Each person will be required to pay full rate for transportation.

VOTE ON THE SOCIETY'S PUBLICATIONS

In accordance with a resolution passed at the last Annual Meeting and a subsequent resolution of the Council, a vote of the entire membership is to be taken on the question of the publications of the Society. It was expected that ballots for this purpose would have been issued before now, but it was decided to defer the matter until a report could be made upon the publications by the Administration Committee. This Committee was appointed in January to "investigate and report back to the Council at an early date upon the economical operation of the Society's administration and also that of the Council." These investigations extend into the various activities of the Society, including the publications, looking to the greatest possible usefulness to the membership as well as the economical administration of the various departments.

In this connection it may be stated that the publication plan which is now being followed includes the publication of the annual volume of Transactions in the 6 x 9 size, as heretofore. Papers presented at the Spring and Annual Meetings are printed in pamphlet form in advance of the meeting and are sent gratis to members requesting them previous to the meeting, due announcement of the papers being made in The Journal.

Following a meeting extended abstracts of the papers are printed in The Journal, together with an account of the discussion, so that the reader may be informed promptly what transpired; and finally the complete, revised papers and discussion appear in the annual volume of Transactions.

Besides this material The Journal contains very complete accounts of the local meetings of the Society, which are now held at intervals in fourteen different cities and which bring to The Journal a large number of valuable papers secured through the efforts of the committees in different sections of the country. An important feature of these papers in relation to the membership at large is that they present the latest engineering developments in the particular locality where the meeting is held, which strengthens the national character of the Society and the comprehensive scope of the papers which it is the privilege of The Journal to publish.

Besides these varied papers The Journal contains from month to month announcements and reports of the Society's activities which, through its committees, are reaching out into broader fields of usefulness. The Journal contains also a review section, including abstracts of foreign articles, and in spite of the curtailment of foreign publications, owing to the unfortunate conditions existing at the present time, this department is able to present from month to month much valuable material on engineering practice.

COUNCIL NOTES

At the meeting of the Council on May 14, 1915, Major William H. Wiley was appointed Chairman and John A. Hill, Vice-Chairman, to represent the Society on a joint committee of the engineering societies, coöperating with the United States Government and Army in the organization of a civilian corps of engineers. These members of the committee are to choose their associates, making a committee of five.

Announcement was made of the appointment of C. M. Allen, Charles T. Main and W. M. White as a committee to consider the merits of a suggested government water wheel testing flume and to report back to the Council.

Voted: That one session of the annual meeting in New York, December 1915, be set aside for a memorial meeting to Frederick W. Taylor, and that a committee composed of Past-Presidents Henry R. Towne, Chairman, Frederick R. Hutton, Alex. C. Humphreys, John R. Freeman and Oberlin Smith, be in charge of this session, at which it is suggested one principal paper be presented to include an account of Mr. Taylor's life and the development of such phases of his work as the Committee may deem proper.

Voted: That Francis H. Richards, W. H. Boehm and H. de B. Parsons be appointed on the Committee on Expert Testimony, coöperating with the American Association for the Advancement of Science, with the request to add two other members of their own choosing.

Voted: In connection with the resolution of the Council of April 9, to refer to the Committee on Public Relations with request to report recommendations to the Council, as a "special committee of five to formulate general principles for the guidance of those who may serve the Society in a representative capacity, and particularly when dealing with public questions."

It was voted to approve an appropriation of $250 towards the development of a Search Bureau in the Library of the United Engineering Society.

Voted: To express to H. de B. Parsons the appreciation of the Council for his report on Fire Hose Specifications, covering the result of appointment as the representative of the Society on a special committee appointed by the Fire Department of the City of New York.

The Secretary read a letter from E. G. Spilsbury reporting the action taken by the engineers committee from the several societies on the constitutional convention. Prof. A. M. Greene, Jr., also reported that the committee had appeared before the convention, that Senator Root had received them and given them a hearing, with the result that the committee is now endeavoring to have these suggestions drafted in the form of various amendments.

Voted: To approve as a committee on meetings in Philadelphia, Robert H. Fernald, Chairman, W. R. Jones, Secretary, E. B. Carter, H. E. Ehlers, J. E. Gibson and A. C. Vauclain, and to approve the appointment of F. W. Gay as a member and Secretary of the committee on meetings in San Francisco to take the place of C. T. Hutchinson who has resigned.

Professor Hutton read a letter acknowledging the receipt by the Institution of Naval Architects, of the draft for 60 pounds, being the amount subscribed by members of the Society and friends of Sir William H. White, toward a memorial fund to honor his memory.

INTERNATIONAL JURY OF AWARDS

PANAMA-PACIFIC INTERNATIONAL EXPOSITION

The group Juries of Award of the Panama-Pacific International Exposition have been in session at San Francisco during the month of May and several members of the Society have served in the various groups, of which the following is as complete a list as we have at present: Guy L. Bayley, George M. Brill, George W. Dickie, Paul Doty, John T. Faig, H. W. Hibbard, John Hunter, Charles T. Hutchinson, Wm. H. Kavanaugh, Frederick R. Low, Charles E. Lucke, Wynn Meredith, Thomas Morrin, C. P. Poole, Calvin W. Rice, Angus Sinclair, Jesse M. Smith, Bradley Stoughton and Max Toltz. The classification of the machinery exhibits is as follows:

Group 85	Steam Generators and Motors Utilizing Steam. Accessory Appliances
Group 86	Internal Combustion Motors.
Group 87	Hydraulic Motors.
Group 88	Miscellaneous Motors.
Group 89	General Machinery and Accessories.
Group 90	Tools for Shaping Wood and Metals.

There are three Juries for the machinery exhibits, aside from the electrical apparatus, of which the officers are as follows:

Group 85 to 88 inclusive, Charles E. Lucke, Chairman, H. W. Hibbard, Secretary.

Group 89, George M. Brill, Chairman, Calvin W. Rice, Secretary.

Group 90, George W. Dickie, Chairman, John T. Faig, Secretary.

PUBLICATION OF THE BOILER CODE

The Boiler Code which was published in pamphlet form the first of March will be sent to every member of the Society in the annual volume of Transactions, to be distributed during the coming summer. In view of its publication in Transactions and of the availability of the report in pamphlet form it is not intended to reprint the report in The Journal. Those desiring pamphlet copies may secure them at 40 cents per copy to members (and to organizations), and 80 cents per copy to non-members. These prices apply to lots of less than 1000. In lots of 1000 to 2000 the price is 30 cents per copy, and in lots of 2000 or over the price is 20 cents per copy, f.o.b. printer, Lyons, N. Y.

PORTRAIT OF ALFRED NOBLE

On April 22 a portrait of the late Alfred Noble, painted by Alphonse Iongers, was unveiled at the Engineers' Club in New York. The portrait is an excellent likeness and fittingly commemorates the personality of the engineer who was so widely known among the profession throughout the country. He was a frequenter of the Engineers' Club, where he met his friends from day to day. Addresses were made at the unveiling by Stevenson Taylor, J. Waldo Smith, Professor Hutton and H. F. DuPuy.

AWARDS OF THE FRANKLIN MEDAL

The Franklin Medal, the highest recognition in the gift of The Franklin Institute, Philadelphia, has recently been awarded to Heike Kamerlingh Onnes, and to Thomas Alva Edison, Mem. Am. Soc. M. E. The awards were made on the recommendation of the Institute's Committee on Science and the Arts, that to Onnes being in recognition of his "long-continued and indefatigable labors in low-temperature research which has enriched physical science, not only with a great number of new methods and ingenious devices, but also with achievements and discoveries of the first magnitude," and that to Edison in recognition of "the value of numerous basic inventions and discoveries forming the foundation of world-wide industries, signally contributing to the well-being, comfort and pleasure of the human race."

The Franklin Medal Fund, from which this medal is awarded, was founded on January 1, 1914, by Samuel Insull. Awards of the medal are to be made annually to those workers in physical science or technology, without regard to country, whose efforts, in the opinion of the Institute, have done most to advance a knowledge of physical science or its applications.

The present awards are the first to be made.

The medal awarded to Professor Onnes was received on his behalf by His Excellency, Chevalier van Rappard, Minister from the Royal Netherlands Government, at the stated meeting of the Institute on the evening of Wednesday, May 19, and at this meeting Mr. Edison was the guest of the Institute and received his award in person. Following the presentations, an address entitled "Electricity and Modern Industrial Growth" was delivered by Mr. Insull.

ANNIVERSARY OF WORCESTER POLYTECHNIC INSTITUTE

The Fiftieth Anniversary celebration of the Worcester (Mass.) Polytechnic Institute will occur from June 6 to 10 in connection with the Commencement exercises, and the character of the celebration will be such as to make the event also a celebration of the achievements of engineering and science.

On Wednesday, June 9, there will be addresses by engineers of international reputation, following which there will be a special meeting of the Local Section of The American Society of Mechanical Engineers, and a banquet in the evening.

General George W. Goethals has accepted an invitation to be present and speak upon the part the civilian engineer has taken in America's outlying possessions, and it is hoped that President Wilson, who was the commencement orator twenty-five years ago and has expressed a desire to attend, may be able to be present. Addresses will also be made by Dr. John A. Brashear, President Lowell of Harvard and Governor Walsh of Massachusetts, and others of wide reputation.

BOILER CODE IN EFFECT IN OHIO

Those who have been interested in the work of the Boiler Code Committee and the development of the Code, the completion of which was announced in The Journal for March, will be interested to learn that it has been put into effect in the State of Ohio. At a meeting of the Ohio Board of Boiler Rules held on March 25, the Code was placed in force by the adoption of the following resolution:

Until further notice an inspector holding a certificate of competency and a commission authorizing him to inspect steam or hot water boilers which are to be installed within the State of Ohio, is hereby authorized to inspect during construction and on completion stamp Ohio STD with serial number any boiler constructed in accordance with the rules formulated by the Boiler Code Committee as submitted to the Council of the American Society of Mechanical Engineers on February 13, 1915.

(Signed) Ohio Board of Boiler Rules,
H. V. NEFF, Chairman.

The State of Ohio has had in force for some time a code of boiler rules which has been very satisfactory, and in consequence, this action is certainly a very strong endorsement of the A. S. M. E. Boiler Code. It should assist very greatly in securing the adoption of the A. S. M. E. Code in other states.

The Boiler Code has also been further endorsed by a meeting of representatives of the American Boiler Manufacturers' Association and of the National Tubular Boiler Association, held in Pittsburgh on March 29, where the report of the Boiler Code Committee was unanimously adopted and ways and means were discussed for promoting the adoption of the standard specifications by the various states. This meeting gives to the Boiler Code a tremendous impetus, as it puts back of it the endorsement of practically the entire boiler manufacturing industry. This marks the climax of a continuous effort for twenty-five years to get a standard specification that would be acceptable to engineers, manufacturers and users of boilers and boiler insurance companies, and these actions would indicate that the Code is in itself as nearly right from a mechanical and engineering standpoint as it is possible to construct such a code.

CLASSIFICATION OF TECHNICAL LITERATURE

Delegates from about twenty national technical and scientific societies met in the United Engineering Society Building, New York, on May 21, to perfect a permanent organization, the purpose being to prepare a classification of the literature of applied science which might be generally accepted and adopted by these and other organizations.

There was a generally expressed opinion that such a classification, if properly prepared, might well serve as a basis for the filing of clippings, for cards in a card index, and for printed indexes; and that the publishers

of technical periodicals might be induced to print against each important article the symbol of the appropriate class in this system, so that by clipping these articles a file might be easily made which would combine in one system these clippings, together with trade catalogues, maps, drawings, blue prints, photographs, pamphlets and letters classified by the same system.

By request, W. P. Cutter, the Librarian of the Engineering Societies' Library, and a delegate from the American Institute of Mining Engineers, read a paper on The Classification of Applied Science, in which, after describing the existing classification, of one of which he is the author, stated that, in his opinion, no one of these, although having excellent features, was complete and satisfactory enough to be worthy of general adoption. He outlined a plan whereby a central office could collate all the existing classifications, and, with the help of specialists in the various national societies interested, might compile a general system which would meet with general acceptance.

The name adopted for this organization is Joint Committee on Classification of Technical Literature, and the officers elected are: Chairman, Fred R. Low; Secretary, W. P. Cutter, 29 West 39th Street, New York; Executive Committee: the above, with Edgar Marburg, H. W. Peck, Samuel Sheldon.

SAN FRANCISCO MEETINGS

That there may be no misunderstanding in connection with the special train, New York to San Francisco, for the International Engineering Congress and the meeting of the Society in San Francisco in September, the Secretary wishes to announce that the special train under the direction of the committee of the joint engineering societies, is via Niagara Falls. The itinerary of this train is as follows:

Thursday, September 9:	
Leave New York (Grand Central Terminal)	7:45 p. m.
Arrive Albany	11:10 p. m.
Leave Albany	11:15 p. m.
Friday, September 10:	
Arrive Niagara Falls, N. Y	7:30 a. m.
Leave Niagara Falls, N. Y	11:30 a. m.
Arrive Chicago, Ill	10:55 p. m.
Leave Chicago, Ill	11:55 p. m.
Sunday, September 12:	
Arrive Colorado Springs, Colo	7:30 a. m.
Leave Colorado Springs, Colo	7:00 p. m.
Monday, September 13:	
Arrive Albuquerque, N. Mex	12:15 p. m.
Leave Albuquerque, N. Mex	1:15 p. m.
Tuesday, September 14:	
Arrive Grand Canyon, Ariz	4:00 a. m.
Leave Grand Canyon, Ariz	7:00 p. m.
Wednesday, September 15:	
Arrive San Francisco, Cal	9:00 p. m.

GENERAL NOTES

An attractive student publication has come to the Secretary in the form of a souvenir number entitled an "Engineer's Special Issue" of the Round-Up, published at State College, New Mexico. This is an eight page paper filled with live matter relating to the college and student activities, but in this issue the bulk of the publication is devoted to the engineering courses and shows by extended articles and numerous half-tone illustrations the work and activities of the engineering school. The publication is unique in its advertising possibilities through its departure from the usual college bulletin.

The inauguration of Edward Kidder Graham as President of the University of North Carolina took place at Chapel Hill, N. C., April 21. He is the tenth president of the oldest state-supported university in the United States and is one of the youngest college presidents. The Society was represented at the inauguration exercises by Park A. Dallis of Atlanta, Ga., who was appointed Honorary Vice-President for the occasion. Among the delegates and visitors who formed the procession were the Governor and Justices of the Supreme Court of North Carolina, Secretary Daniels of the Navy, in addition to the past-presidents and faculty of the University.

Several complaints have come to this office of men who have posed as members of the Society and have attempted to borrow money on the strength of their membership. Three such cases have come to our attention and members are warned that they should be on their guard against such forms of imposition. A person thus representing himself should at least be able to show his membership card as evidence of sincerity.

APPLICATIONS FOR MEMBERSHIP

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their age would qualify them and not with regard to professional qualifications, i.e., the age of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are qualified for Junior grade only. Applications for change of Grading are also posted. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into the Membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received before July 10, 1915.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

ALLEN, JESSE B., Ch. Engr. and Master Mech., Tuttle & Bailey Mfg. Co., Brooklyn, N. Y.

BUTLER, WILLIAM A., Asst. Supt. Pwr. Stas., Duquesne Light Co., Pittsburgh, Pa.

BIGLOW, LEMUEL CAVALLI, Mgr., New York Office, Morse Chain Co. of Ithaca, New York, N. Y.

BJORNSSON, CARL A., Desinging Engr., The McIntosh & Seymour Corp., Auburn, N. Y.

CLARK, HAROLD H., Local Mgr., Link-Belt Co., Los Angeles, Cal.

DAVISSON, WOODFORD, Ch. Engr., Rancho La Brea Oil Co., Los Angeles, Cal.

FLANNER, DOUGLASS D., Treas. and Genl. Mgr., Flanner Water Tube Boiler Co., Akron, Ohio.

GOODWIN, E. CLAYTON, Supt., Hart & Cooley Co., New Britain, Conn.

GREIST, HUBERT MILTON, Secy. and Supt., The Greist Mfg. Co., New Haven, Conn.

GRIFFITH, LEIGH M., Mgr. and Co-Partner, Griffith Mch. Wks., Los Angeles, Cal.

HALL, WINTHROP G., Asst. Supt., Spencer Wire Co., Worcester, Mass.

HAYES, RALPH W. E., Mech. Engr., Hayes Pump & Planter Co., Galva, Ill.

HICKS, GEORGE C., JR., Vice-Pres. and Engr., P. H. & F. M. Roots Co., Connersville, Ind.

HOWE, JAMES F., Asst. to Dist. Mgr., American Steel & Wire Co., Worcester, Mass.

JOHNSON, CHARLES L., Clerical Supt., Western Elec. Co., Hawthorne Sta., Chicago, Ill.

KIDD, GEORGE F., Engrg. Dept., The New York Edison Co., New York.

LANG, CHARLES W., Supt., Defiance Mfg. Co., Summerdale, Philadelphia, Pa.

LAWTON, B. L., Treas. and Genl. Supt. of Factory, Conn. Tel. & Elec. Co., Meriden, Conn.

LAWTON, CHARLES L., Genl. Mgr., Quincy Mine, Hancock, Mich.

LITCHFIELD, H. L., formerly Elec. Engr., Choralcelo Co., Boston, Mass.

LORD, ZENAS N., Dept. Foreman, General Elec. Co., Lynn Wks., West Lynn, Mass.

MCGOWAN, HENRY E., Asst. Secy., The Brooklyn Union Gas Co., Brooklyn, N. Y.

MALM, AXEL C. V., Supt., The Egry Register Co., Dayton, O.

MAXWELL, HOWARD, Engr., General Elec. Co., Schenectady, N. Y.

MULLIN, JOHN T., Mech. Draftsman, Mead-Morrison Mfg. Co., Chicago, Ill.

PARK, EDWIN HERVEY, Asst. to Master Mech., Wright Wire Co., Worcester, Mass.

PERKINS, EDWIN A., Mech. Engr., The Norma Co. of America, New York.

SCOTT, ROSSITER STOCKTON, Engr., Consolidated Gas, Elec. Light & Power Co., Baltimore, Md.

THOMPSON, CHARLES F., Maintenance Engr., The Aultman & Taylor Mchy. Co., Mansfield, O.

TYLER, WARREN C., N. Y. Mgr., Poole Engrg. & Mch. Co., Woodberry, Baltimore, Md.

WOLFF, JOHN, Mech. Engr., Cleveland Elec. Ill. Co., Cleveland, O.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

ARMSTRONG, HENRY C., Insptr. of Materials for Panama Canal, Washington, Pa.

BROWN, MELVILLE G., Pres., Northern Telephone & Pwr. Co., Ltd., Prince George, B. C., Canada.

GOODKIN, SAMUEL J., Efficiency Expert, Cincinnati Milling Mch. Co., Cincinnati, Ohio.

GROUT, ALVAN LORY, Asst. Mech. Engr., Remington Typewriter Wks., Ilion, N. Y.

HENSZEY, ROY O., Genl. Engr., Pacific Coast Condensed Milk Co., Oconomowoc, Wis.

HETZEL, ROLAND F., formerly Ch. Designer, Puget Sound Mchy. Depot, Seattle, Wash.

LORD, HARRY C., Engr., with John A. Stevens, Cons. Engr., Lowell, Mass.

REBBEKE, ERNEST A., Ch. Draftsman, Mech. Div., Panama Canal, Balboa, C. Z.

RUSSELL, WALTER W., Foreman, Jones & Lamson Mch. Co., Springfield, Vt.

TILLSON, BENJAMIN F., Head of Min. Dept., New Jersey Zinc Co., Franklin Furnace, N. J.

VAN WINKLE, HOWARD E., Territory Mgr., Overland Automobile Co., Manhattan, Kan.

FOR CONSIDERATION AS JUNIOR

BARDROF, FRANK E., Asst. in Mech. Engrg., Rensselaer Poly. Inst., Troy, N. Y.

BARR, KESTER, Special Rep., Lumen Bearing Co., Buffalo, N. Y.

BISSELL, HARRIE G., Engr. and Draftsman, Munising Paper Co., Munising, Mich.

BOSTWICK, W. WALKER, Specl. Apprentice for Engrg. Salesman, Ingersoll-Rand Co., Phillipsburg, N. J.

BREED-LOVE, LINCOLN B., Instr., Robert College, Constantinople, Turkey.

DAVIES, CLARENCE E., with Remington Typewriter Co., Syracuse, N. Y.

HOWE, RALPH S., Engr. Mitchell Vance Factory, H. W. Johns-Manville Co., New York.

HOWELL, KENNETH B., Engr., Barrett Mfg. Co., New York.

KAPLAN, HARRY, Draftsman, Interborough Rapid Transit Co., New York.

MILES, FRANK HAROLD, Foreman and Designer, The Milton Mfg. Co., Milton, Pa.

MILLER, FRED M., Post Grad. Work, University of Ill., Urbana, Ill.

MULLANEY, JOHN E., with Lewiston Bleachery & Dye Works, Lewiston, Me.

PATERSON, LESTER B., Elec. Tester, Van Nest Elec. Repair Shops, N. Y., N. H. & H. R. R. Co., Van Nest, N. Y.

ROBBINS, WALTER C., Mech. Engr., Young's Oil Co. of Scotland, San Francisco, Cal.

ROLLINS, LEONARD E., Cons. Engr. Mech. Equipment for Bldgs., Minneapolis, Minn.

RUGG, DANIEL M., Supt., Chattanooga Gas & Coal Products Co., Chattanooga, Tenn.

SEGALOWITZ, OSCAR, Mech. Engr., The American Paper Goods Co., Kensington, Conn.

SHIREY, WILLIAM H., Draftsman, McMeans & Tripp, Cons. Engrs., Indianapolis, Ind.

STONE, E. WADSWORTH, Insptr, International Typesetting Mch. Co., New York.

TOPPIN, JOHN MARTIN, Asst. Mech. Engr., Small Motor Dept., General Elec. Co., Pittsfield, Mass.

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM JUNIOR

FELKER, GEORGE F., N. Y. Rep., Pittsburgh Valve, Fdy. & Constr. Co., New York.

MORRISON, HUNTER, Sales Mgr., The Hill Clutch Co., Cleveland, Ohio.

PROMOTION FROM ASSOCIATE

FLINN, CHARLES F., Cons. Engr., San Francisco, Cal.

SUMMARY

New applications	62
Applications for change of grading:	
Promotion from Junior	2
Promotion from Associate	1
	65

MODERN ELECTRIC ELEVATOR AND ELEVATOR PROBLEMS

BY DAVID LINDQUIST[1], NEW YORK

Non-Member

THE elevator art has gone through quite a number of more or less radical changes, particularly in the last fifteen years. These changes have been partly due to developments in building construction, utilizing steel as building material, thereby making it possible as well as practical to erect high structures. At the same time, it cannot be denied that the simultaneous development of commercial elevators particularly for high speed, has materially aided in the development of modern buildings.

The tall buildings of New York have been made possible by the development in elevators

Elevators may be classified according to the driving power employed: Steam driven elevators; Hydraulic elevators, and Electric elevators.

The first class, namely, steam elevators, is at the present time practically obsolete. There are, of course, quite a few of them still in existence and running, but there are no new plants of this type being installed at the present time.

Hydraulic elevators may be divided into several groups, depending upon the different methods in which the hydraulic power is transmitted to the elevator car. Some of the principal and well-known types are: The horizontal hydraulic (rope geared); the vertical hydraulic (rope geared), and the plunger hydraulic (direct connected). These types have been mentioned in the order they were introduced for high speed in comparatively high buildings. The plunger type practically superseded other types of hydraulic elevators during the period of 1904 to 1907, and in turn the plunger has now been almost entirely superseded by the gearless 1:1 traction type of electric elevator.

Without considering in detail the technical features of the plunger elevator in comparison with the gearless electric traction type, the principal reasons for this change in elevator practice may be summarized as follows:

a Higher initial cost of a plunger installation.

b Larger amount of total space in the building occupied by the machinery.

c Lower car mileage and consequently more elevators required for the same service.

d Higher power consumption.

The principal features of both the gearless and gear traction type of elevators will be described, the gearless, however, being treated more in detail.

Location of Machine. When considering the installation of the traction electric elevator the first question which arises is as to where the machine may most suitably be placed. There is no question but that placing the machine directly over the hatchway, as indicated in Figs. 2 and 3, is the most suitable arrangement. With this overhead location the best results are obtained, and the principal advantages may be enumerated as follows: better traction, less amount of rope, longer rope life, minimum space required, and higher efficiency.

It will be perfectly plain, if one stops to consider, that placing the machine directly over the hatchway will impose less load on the building than if the same machine were placed below. Placing the machine directly above the hatchway imposes a load on the building equal to the weight of the hoisting machine plus the loads on car and counterweight ropes, whereas placing the machine below, imposes a load on the building equivalent to twice the loads on the car and counterweight ropes. For a duty of 2500 lb. at 700 ft. per min., the hoisting machine weighs about 16,000 lb., which is considerably less than the total load on car and counterweight ropes.

In the above example, the machine, due to high speed, is quite heavy in proportion to the load. A machine intended for lower speed would weigh still less and make the difference in loads imposed upon the building, to which attention is called, even more apparent.

Locating the machine above also takes up less space in the building than locating it elsewhere. It also somewhat prolongs the life of the ropes, as by this arrangement the rope is not subjected to so many bends. Placing the machine overhead also increases the overall efficiency of the installation.

Roping. The next consideration is that of roping. The roping of a so-called gearless 1:1 traction machine located overhead is extremely simple, as indicated in Fig. 4.

The principle of the traction drive is no doubt very old but its commercially successful application to an elevator

[1] Chief Engineer, Otis Elevator Company.

Presented at the New York local section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, on April 13, 1914.

machine, consisting of a slow speed electric motor directly connected to the driving sheave, was first accomplished about ten years ago. Some attempts had previously been made, particularly by Duwelius, who built two, or possibly three, machines. For a number of reasons, however, they were not considered practical and he finally abandoned the attempt,

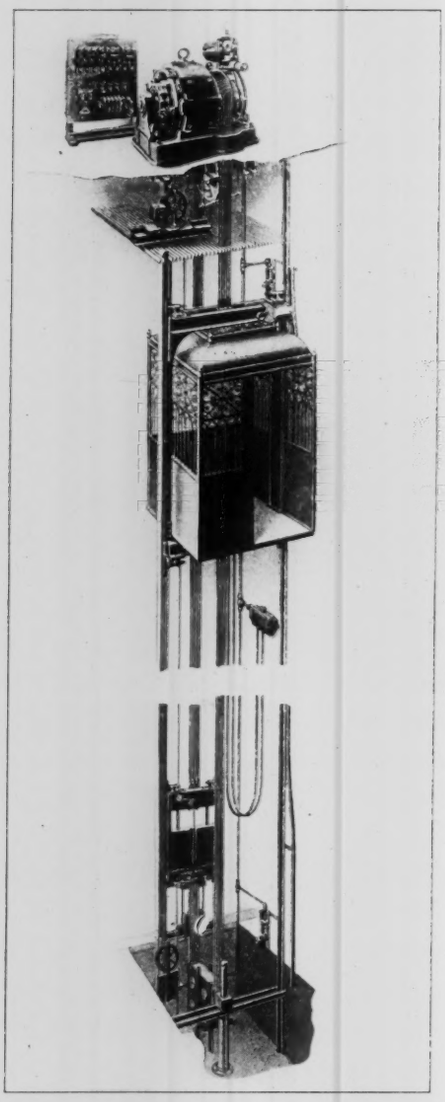


FIG. 2 ARRANGEMENT OF APPARATUS IN A TYPICAL GEARLESS TRACTION ELECTRIC ELEVATOR INSTALLATION

for apparently he could not produce a successful gearless electric elevator machine.

At first glance, it would appear as if the traction drive would be rather uncertain, when considering that the ropes are not actually hitched to the driving member, that they simply go around the driving sheave of the motor, and depend solely upon the friction, or adhesion between the ropes and the driving sheave. This, however, is not the case; on the contrary, it is safer than any other method of drive.

Before any of these traction machines were put on the market, a large number of tests were made under such variable conditions as would be encountered in actual installations. It was found that with one-half wraps around the driving sheave the maximum traction relation—that is, the relation between the load on the heavy side of the ropes to that on the light side—was 1.56, and the minimum traction relation, with one-half wraps was 1.4. With two half wraps as indicated by diagram, Fig. 4, the maximum relation is 2.43 and the minimum 1.96; the increase being of course in logarithmic proportion.

The maximum was obtained with a new turned sheave with practically new ropes and without any lubrication. The minimum was obtained with smoothly-worn sheave and ropes well lubricated, and with comparatively light tension and high speed. The principal reasons for this result are that with light tension and high speed there is an oil film between the rope and the sheave; moreover, the rope does not make contact fully 180 deg. with the sheave, due to the stiffness of the rope and centrifugal action.

The small variation, or the constancy of the traction is quite remarkable, and as long as the maximum variations in

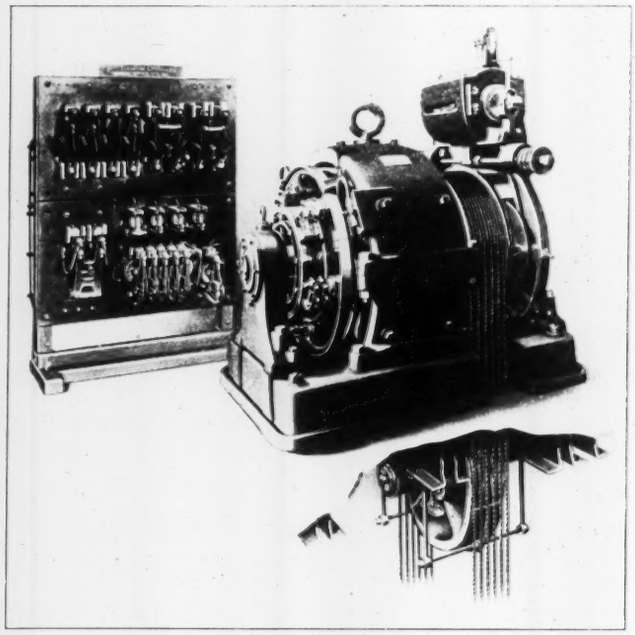


FIG. 3 DETAIL VIEW OF THE OVERHEAD INSTALLATION OF A GEARLESS TRACTION ELECTRIC ELEVATOR

the load on a traction type elevator are such as not to require more than the minimum possible traction relation above mentioned, no slipping can occur.

Under ordinary conditions a 1:1 traction machine is usually provided with six ropes $\frac{5}{8}$ in. in diameter. The material is of soft steel, and in actual installations this will give a safety factor of not less than twelve.

Each rope is provided with a self-adjusting swivel rope hitch of the ball and socket type. This permits a gradual creeping and thus prevents any excessive twisting strain, and relieves the rope of the bending strains at the hitch, principally caused by vibration.

The traction method of drive has a number of inherent safety features. Traction elevators are arranged so that in case of overrun at terminals, either the car or counterweight bottoms on a buffer, thereby reducing the traction sufficiently to pervent further motion of the car and counter-

weight, even if the motor keeps on running. The car buffer is usually an oil buffer of a spring return type and mounted in the bottom of the pit, as illustrated in Fig. 5. As shown in Fig. 4, the counterweight buffer is mounted on the counterweight, and acts also as counterbalance. This latter buffer has gravity return, whereas the car buffer has spring return.

For very high rises, the great weight of the hoisting rope will cause considerable traction, even after the car or counterweight has landed on its buffer. This traction, together with the momentum of the car or counterweight, may cause either of them to travel into the overhead work, under conditions of runby clearance usually available. To prevent

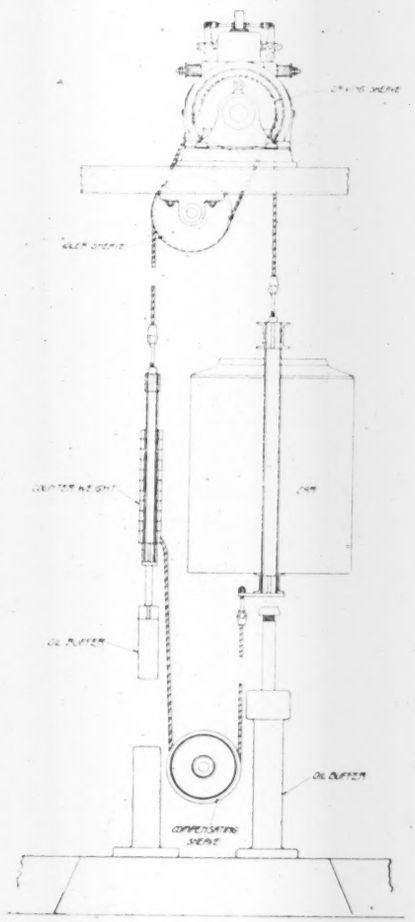


FIG. 4 DETAILS OF THE ROPING OF A TYPICAL GEARLESS 1:1 TRACTION ELEVATOR

this, some of the exceedingly high rise buildings are equipped at the top of the hatchway with a retarding and latching device for both car and counterweight, in addition to the regular oil buffers acting in the pit. In case of abnormal overrun, the retarder brings either car or counterweight to rest and the latching device prevents subsequent downward movement.

Counterweight and Rope Compensation. The counterweight, the mechanical construction of which may be seen in Fig. 2, equals in total weight the weight of the car plus usually about 40 per cent of the maximum load. If we consider an elevator of 2500 lb. lifting capacity, 40 per cent of this equals 1000 lb. (the overbalance) and this represents about six or seven persons. Thus, with six or seven persons in the car, giving balanced condition, it is apparent there would be no *net load* to be lifted and the only power required would be for acceleration and for overcoming friction and electrical losses.

It is obvious that with a high rise elevator the variation in the net load on the elevator machine due to the shifting of the weight of the hoisting ropes from one side to the other of the driving sheave as the car moves up and down, would be excessive if this were not compensated for. This compensation is usually obtained by means of chains or ropes attached to the car and counterweight, and running down the

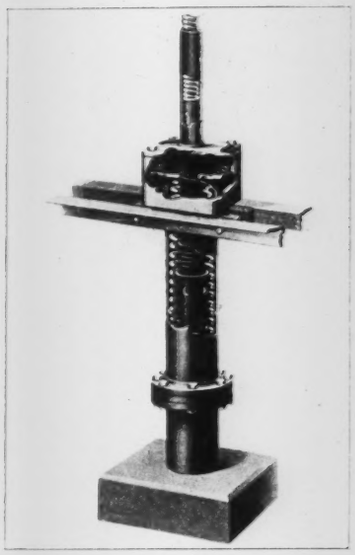


FIG. 5 DETAIL VIEW OF CAR BUFFER OF THE SPRING RETURN TYPE

hatch in a loop. In Figs. 2 and 4 may be seen the compensating ropes running down from the bottom of the car to the tension sheave in the pit and up to the counterweight. The weight per foot of these compensating ropes is such that they, together with the electric cables (that lead to the car), will compensate the weight of the hoisting ropes regardless of the position of the car.

For all high speed high rise elevators, compensating ropes are used. In the pit a tension device is provided for the compensating ropes. For moderate rises and comparatively slow speeds, chains may be used instead of ropes.

Driving Motor. The electric motor is of the slow speed type, generally six pole and usually provided with shunt field only. The armature is series-wound with conductors of rectangular cross section, in order to get the maximum amount of copper in the armature. With a 36 in. driving sheave, a car speed of 600 ft. per min. corresponds to 63.6 r.p.m. of the motor. Figs. 6 to 9 show the compact design of the motor, and Figs. 8 and 9 show machines provided with ball bearings, which it may be seen are shorter than the regular babbitted bearings. The principal features of the motor with driving sheave, commutator, electro-mechanical brake, brake shoes, etc., are clearly illustrated.

Up to even a comparatively late date, it seems to have been the general impression that a motor of moderate duty, having a speed so exceedingly low as that required for this

gearless type of elevator, would have also a low efficiency; but this is not the case. On the contrary, it has been demonstrated, and proven a number of times, that a motor with this low speed can be designed to have just as high efficiency as any high speed motor of equal output. One peculiar feature about the efficiency of this motor is that it is unusually high at light loads. This is particularly of advantage in connection with elevators where the average load on the motor is usually less than one-half its rating.

The curve in Fig. 10 shows the result of a test on a traction motor installed in the Metropolitan Life Tower. This motor was rated at 38 h.p., at which full load capacity an efficiency of 89 per cent may be observed. At half load, the motor shows an efficiency of 91.5 per cent and at quarter load

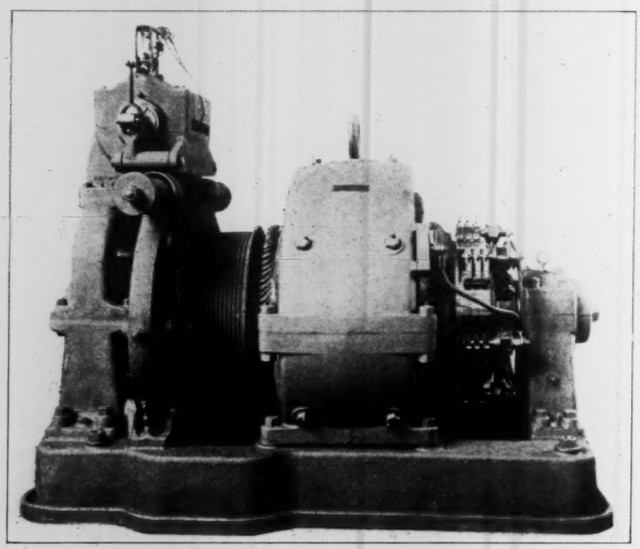


FIG. 6 A TRACTION ELECTRIC ELEVATOR MACHINE OF THE 1:1 TYPE

over 90 per cent. It may be said that these are uncommonly high efficiencies for a motor of 38 h.p. capacity, designed for a speed of 58 r.p.m. at 110 volts.

The curve in Fig. 11 shows the result of a test of a traction motor installed at the 181st St. Subway Station in N. Y. City. This curve shows that the motor has a maximum efficiency of 93 per cent at about half output and illustrates still better the remarkable results that can be obtained with motors of abnormally slow speed for comparatively small outputs. These efficiencies are, as a matter of fact, considerably higher than is usually obtained in high speed motors of corresponding horse power; particularly is this true with light loads. Further reference to motor efficiency will be made in connection with power consumption.

The driving sheave is commonly about 36 in. in diameter, and the driving sheave and brake wheel are of the rim type, cast integral and bolted to the armature sleeve or spider. Circular rope grooves are employed. The brake is of the shoe type, and the magnet is usually provided with series-winding for quick release, and with a shunt-winding for holding. The brake shoes are provided with a lining of fabricated asbestos. A gradual and soft application of the brake is obtained by a particular method of magnetic retardation of the magnet cores, eliminating thereby the necessity for dash pots. The brake shoes were formerly, for some time, lined with leather, but after very exhaustive tests of a number of different brake lining materials, it was found that a certain kind of fabricated asbestos was the most suitable. The particular qualities or characteristics of this brake lining are, that the friction between the lining and the wheel is practically constant at all times. Tests have been made and the temperature ran up to about 400 deg. cent., but there was no appreciable variation in the friction. Furthermore, the coefficient of friction is very constant, varying but little with variations in speed. The variation is remarkably small as compared with leather. With leather, it was frequently noticed that the machine would come almost to a stop, and then creep, just as in the case of a hydraulic elevator with a slight leakage of water. This was due to the fact that the friction coefficient between the leather and the brake wheel was very much lower at slow speed than at high, the minimum being obtained at practically zero speed.

Bearings. The bearings are either of the ordinary babbitt lined, self-aligning type, with automatic chain-oiling, or are of the anti-friction type (ball or roller bearings). Elevators of the gearless traction type have been for some time equipped with ball or roller bearings, which are used for both the main motor, and rope sheave bearings. They were

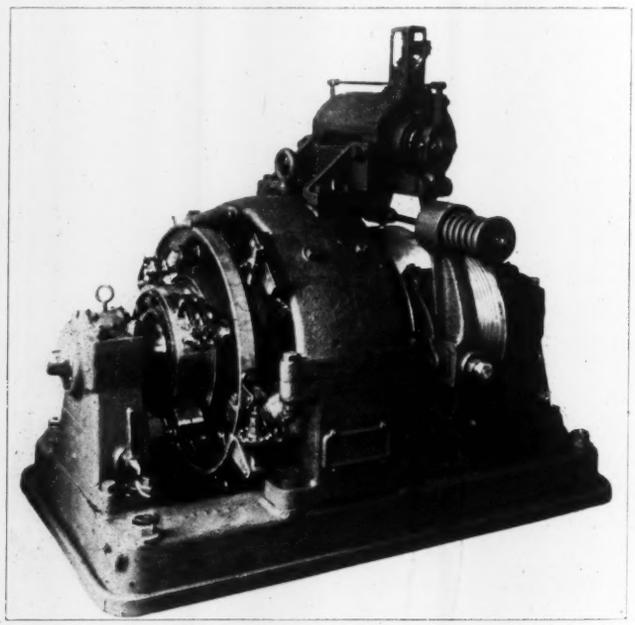


FIG. 7 A TRACTION ELECTRIC ELEVATOR MACHINE OF THE 2:1 TYPE

adopted primarily to gain space, and it is readily apparent that these anti-friction bearings take up much less room than the plain solid bearings. It followed therefore that a traction machine equipped with them could be designed to take up less space, and thus, in many instances, eliminate the necessity for double decking an installation consisting of a number of adjacent elevator machines; by "double decking" is meant the placing of machines on two levels, when the machine is longer than the center distance between adjacent hatchways, thus preventing their installation on one level.

In the case of elevators with 2:1 roping, this saving in space in connection with the sheaves, really becomes a neces-

sity; for here, particularly in the counterweight sheave where space conditions are always limited, a plain babbitted bearing of suitable capacity would be practically impossible. Of course, the use of these anti-friction bearings also introduces other very decided advantages,—materially reducing friction, particularly at starting, and introducing a smoothness of operation superior to plain bearings. This is again particularly applicable to the sheaves used with machines having 2:1 roping, for here the additional number of sheaves requires that the friction be reduced to a minimum.

As to the relative merits of ball or roller bearings, opinions differ greatly. Personally, I consider ball bearings, at the present time, superior to roller bearings for electric elevator machines. My reasons for this are based upon considerable investigation which has convinced me that ball bearings can be successfully and practically produced of sufficient capacity to withstand the service imposed. Further than this, ball bearings possess the inherent advantage of being able to run slightly out of alignment without causing destructive strains or excessive friction. With roller bearings slightly out of alignment, even though this be not sufficient to set up destructive strains, the friction will be increased very materially. As a matter of fact, actual tests

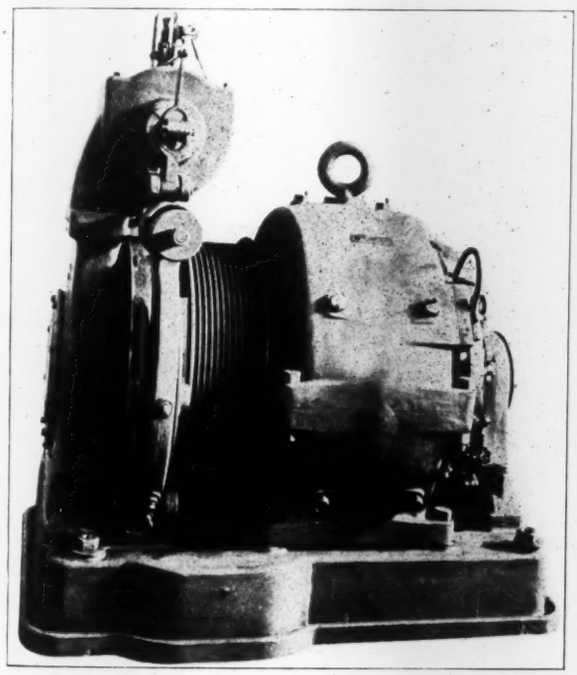


FIG. 8 A TRACTION MACHINE OF THE 1:1 TYPE FITTED WITH BALL BEARINGS

have shown that friction induced in this manner can readily be in excess of the friction in a plain bearing. Furthermore, ball bearings are capable of resisting a certain amount of end thrust; quite sufficient, in the case of these traction machines, to take care of the "float" of the armature, partly due to magnetic action, and added to by the action of the hoisting ropes. Roller bearings will permit of no end thrust at all, and therefore when they are used, additional means must be provided to take care of this.

The introduction of ball bearings in connection with elevator machinery was something of an innovation, and entailed the use of bearings of considerable size and strength. At the start, the ball bearing manufacturers apparently and unfortunately did not fully appreciate the special features of design that were required, with the result that some of the earlier bearings of this type were not as suitable as they might have been, or are to-day. However, even taking this fact into consideration, there have been, in proportion to the large number used, very few that have proved unequal to the duty imposed upon them. It is pleasing here to record that while at the start it was supposed that the foreign-made ball bearing represented the highest state of development, to-day the American product has proved itself by far the best that can be obtained.

The total losses in ball bearings may be considered due to three distinct causes; namely, rolling friction, sliding friction

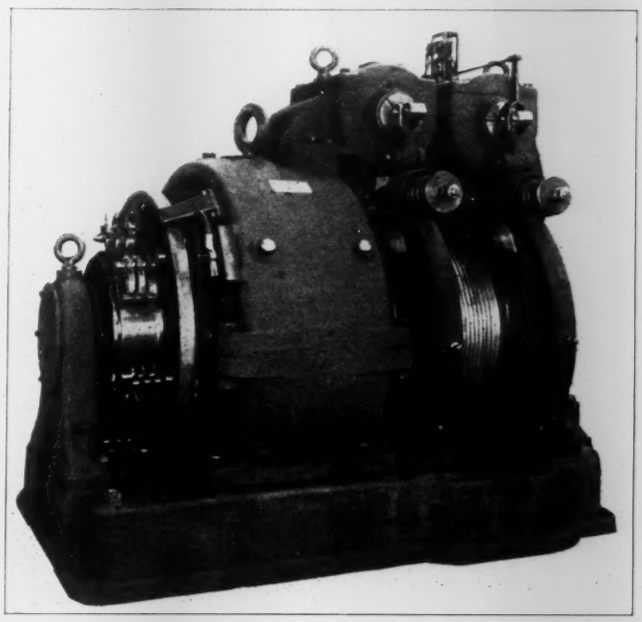


FIG. 9 A SAFE-LIFT TRACTION MACHINE FITTED WITH BALL BEARINGS

and losses caused by the lubricant. The rolling friction is that loss due to the slight deformation of the balls and their races; this loss is exceedingly small. The sliding friction occurs between the balls and their cage, and to a slight extent between the balls and the races; this latter is occasioned by the differing velocities at various points of contact between the balls and the races, due to deformation. The sliding friction between the balls and their cage in a radial type of bearing is also very small, and consideration of the sliding friction between balls and races may usually be neglected unless the difference in velocities is considerable, as may be the case in the use of ball bearings with close fitting races, heavily loaded.

Paradoxical though in sound, it should be noted that the principal loss in ball bearings is that caused by the use of a lubricant. This loss, of course, depends upon the viscosity of the lubricant and increases greatly with the speed. It is due partly to the churning of the lubricant and partly to the force necessary to squeeze it out of the path of the balls. The main reason for its use is for protecting the bearings from corrosion. The best protection for slow speed bearings is obtained by the use of a moderately heavy grease which

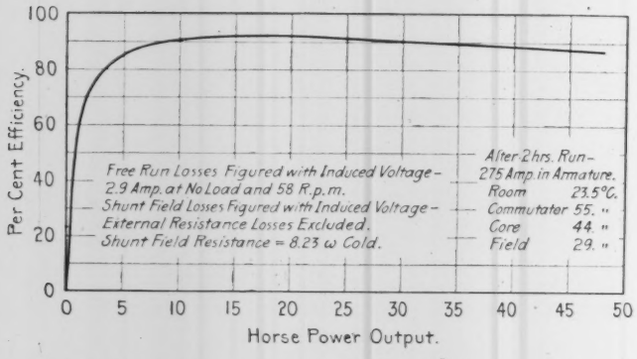

Per Cent Efficiency.
Horse Power Output.
Free Run Losses Figured with Induced Voltage – 2.9 Amp. at No Load and 58 R.p.m.
Shunt Field Losses Figured with Induced Voltage – External Resistance Losses Excluded.
Shunt Field Resistance = 8.23 ω Cold.
After 2 hrs. Run – 275 Amp. in Armature.
Room 23.5°C.
Commutater 55. "
Core 44. "
Field 29. "

FIG. 10 EFFICIENCY TEST OF A TRACTION MOTOR IN THE METROPOLITAN LIFE TOWER

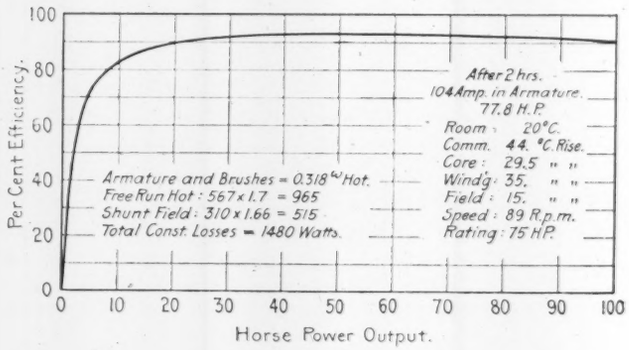

Per Cent Efficiency.
Horse Power Output.
Armature and Brushes = 0.318 ω Hot.
Free Run Hot: 567 x 1.7 = 965
Shunt Field: 310 x 1.66 = 515
Total Const. Losses = 1480 Watts.
After 2 hrs. 104 Amp. in Armature. 77.8 H.P.
Room 20°C.
Comm. 44. °C. Rise.
Core: 29.5 " "
Windg: 35. " "
Field: 15. " "
Speed: 89 R.p.m.
Rating: 75 H.P.

FIG. 11 EFFICIENCY TEST OF A TRACTION MOTOR AT THE 181ST ST. SUBWAY STATION, NEW YORK

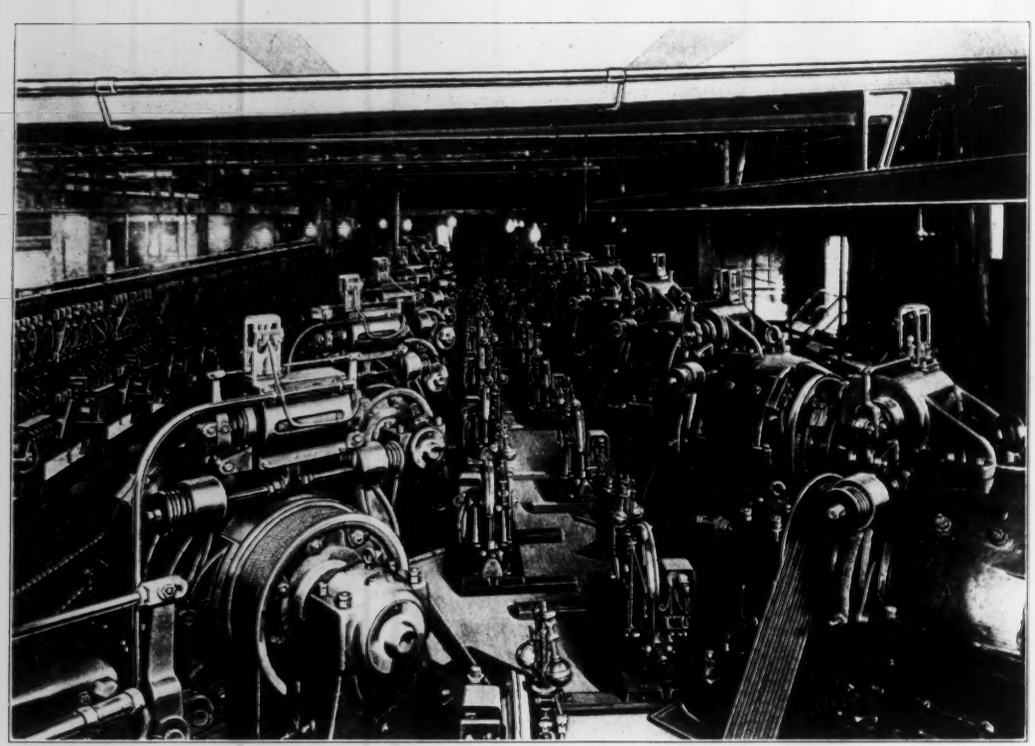


FIG. 12 TYPICAL OVERHEAD INSTALLATION OF TRACTION ELECTRIC ELEVATOR MACHINES WITH PLAIN BABBITTED BEARINGS

will not flow. Protection from corrosion is important since a speck of rust may soon ruin a bearing. The lubricating properties also reduce wear.

Method of Control. Figs. 14 and 15 show controllers used in connection with 1:1 and 2:1 traction elevators and Fig. 16, an installation of a large group of controllers. The speed variation necessary in connection with high speed traction elevators is obtained, partly by field regulation and partly by series and by-pass resistance in the armature circuit. The field regulation is usually capable of reducing full speed down to a speed from 60 to 40 per cent of full speed; further slow-down is obtained by resistance control.

The combination of the two methods mentioned is necessary for obtaining sufficiently slow car speed (about 90 ft. per min.). This slow speed is required for making accurate stops both at intermediate and terminal landings, and also in order to make a very short travel, or to "inch" up or down, to the landing. The exceedingly slow speed automatically obtained when approaching terminal landings is necessary not only to secure accuracy of stops with varying loads, but to provide a fundamental safety feature. It may be mentioned that anti-friction bearings not only materially aid in obtaining smoothness of operation but greatly facilitate the "inching" up to the floor landings.

As a matter of fact, the 1:1 electric traction machine with ball bearings, has practically the smoothness of motion when running, starting and stopping, so much appreciated in hydraulic elevators; yet it comes to a positive stop without the objectionable oscillation and subsequent creeping, inherent in hydraulic elevators.

In connection with the regular operating features of the control apparatus, there are also a number of other features introduced for the purpose of safety. Some of these may be merely mentioned without going into too great detail:

a Automatic return of car switch to "off" position.

b Automatic stopping switch on car for automatic stopping at terminal landings.

c Final cut-out limit switches in hatchway operating independently of the automatic stopping switch.

d Switches operated by centrifugal governor automatically stopping the elevator in case of overspeed; the first switch cuts the power off from the machine and applies the dynamic brake effect to the armature, and applies the mechanical brake to the brake pulley; the second switch applies the light retarding force to the car safety referred to later under the subject of electro-mechanical safety.

e The safety switch in the car under the control of the operator also performs the same function as the two switches operated by the governor.

f Regulation of shunt field by centrifugal governor to maintain constant full speed with variable loads.

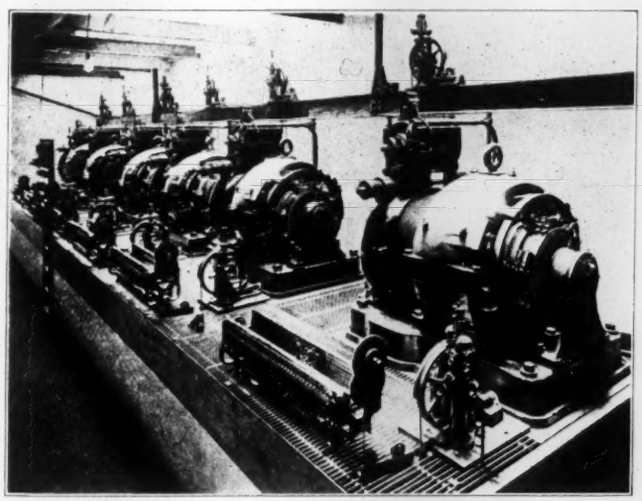


FIG. 13 AN INSTALLATION OF BALL-BEARING TRACTION MACHINES

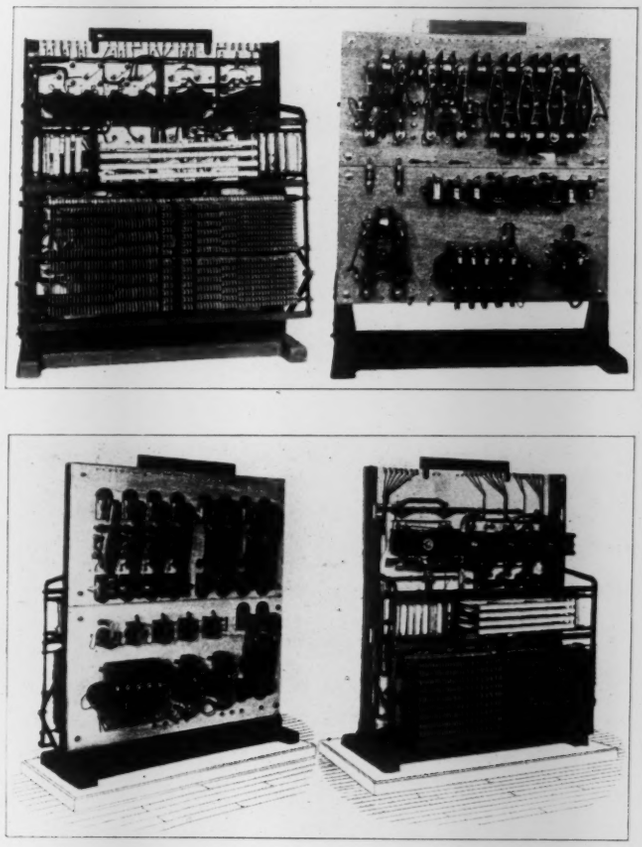
g Oil buffers as previously mentioned, capable of independently stopping the fully loaded car when descending at 50 per cent excess speed without discomfort to the passengers.

h For high rise elevators the use of a mechanical retarding and latching device.

Fig. 17 shows the switch located on the car to effect the automatic stop at terminal landings. This switch is provided with a lever actuated by two cams in the hatchway, one at the upper landing and one at the lower.

Loads and Speeds.—Gearless traction machines, utilizing 1:1 or 2:1 roping, have been built for loads varying from 2000 lb. up to 11,000 lb. at car speeds from 350 up to 700 ft. per min. Of these duties the most generally used for the modern high office building, utilizing 1:1 roping, is about 2500 lb. at a speed of 600 or 700 ft. per min., although in many instances, a speed of 500 to 550 ft. per min. is found suitable.

The speed of the high rise elevators in the Woolworth Building is 700 ft. per min., which is at present the highest elevator speed permissible in New York City. In the new Equitable Building in New York, certain of the elevators are arranged to run a portion of their travel on express service at a speed of 650 ft. per min. and the rest of their travel on local service at 550 ft. per min. The change in car speed is automatically accomplished at the point in the hatchway where the character of the service changes. The point at which this change in speed occurs can readily be altered at any time to suit the requirements of the building. The owners of this building considered that a change in speed as just described would be advantageous, and no doubt this will prove to be the case. Reference to the curves in Fig. 18 will make the fact apparent that a reduction in speed from that of the express run, is desirable when the elevator is running



FIGS. 14-15 TYPICAL CONTROLLERS USED WITH TRACTION ELECTRIC ELEVATOR MACHINES

in local service. The advantage is found in a reduction of power consumption without an appreciable loss of service time.

The curves in Fig. 18 were produced from tests of the elevators installed in the Metropolitan Life Tower. They show the relation between time and speed, both for express runs and for stopping at every floor; ascending and descending with full load. It will be noted that the maximum speed attained when stopping at every floor is only about 70 per cent of the full speed attained during express run. This is, however, a rather extreme case as the car was very heavy, the ropes were long and consequently the masses to be accelerated were unusually great.

For more moderate speeds and heavier loads, a 2:1 roping of car and counterweight is utilized (shown diagrammatically in Fig. 19), which retains the safety features and general characteristics of the 1:1 equipments. For moderately high

buildings, this 2:1 roping is suitable for a car speed not in excess of 450 ft. per min.

Geared Machines. The traction principle is also applicable to elevator machines employing moderately high speed motors with some form of gearing between the motor and driving sheave. Machines of the geared type are most suitable when lower speeds are involved or where the service conditions are not so severe. Under these conditions the power consumed will be comparatively small on account of the lesser mileage, and hence the more expensive gearless machine with its reduced power consumption may not be necessary.

As far as smoothness of operation is concerned, a geared machine can obviously never equal that of a gearless, on account of the fact that it is practically an impossibility to manufacture any kind of gears which are perfect, and mount the same in absolute alignment. Furthermore, if this condition of perfection could be established, it could not be maintained in service, on account of the inevitable wear that would take place.

Two types of geared machines have been developed, one employing worm gear and the other herring-bone gear reduction (see Figs. 20 and 21). Of these two, the worm geared is suitable for slow and more moderate speeds, and is used extensively for this purpose. The machine with herring-bone gear reduction is of course not suitable for slow car speeds on account of the difficulty in obtaining sufficient speed reduction. Undoubtedly, it is somewhat more efficient than worm gearing, and has been used with some success in connection with quite high speed elevators. The fact that the herring-bone geared machine has been used for these high speeds should not be understood as indicating that it is equal to the gearless machine, with which it cannot compare as to operating features and power consumption.

Of the two kinds of gears mentioned, the worm gear has inherently less tendency to vibrate than the herring-bone gear. On the other hand, the herring-bone gear is generally more efficient than the worm gear.

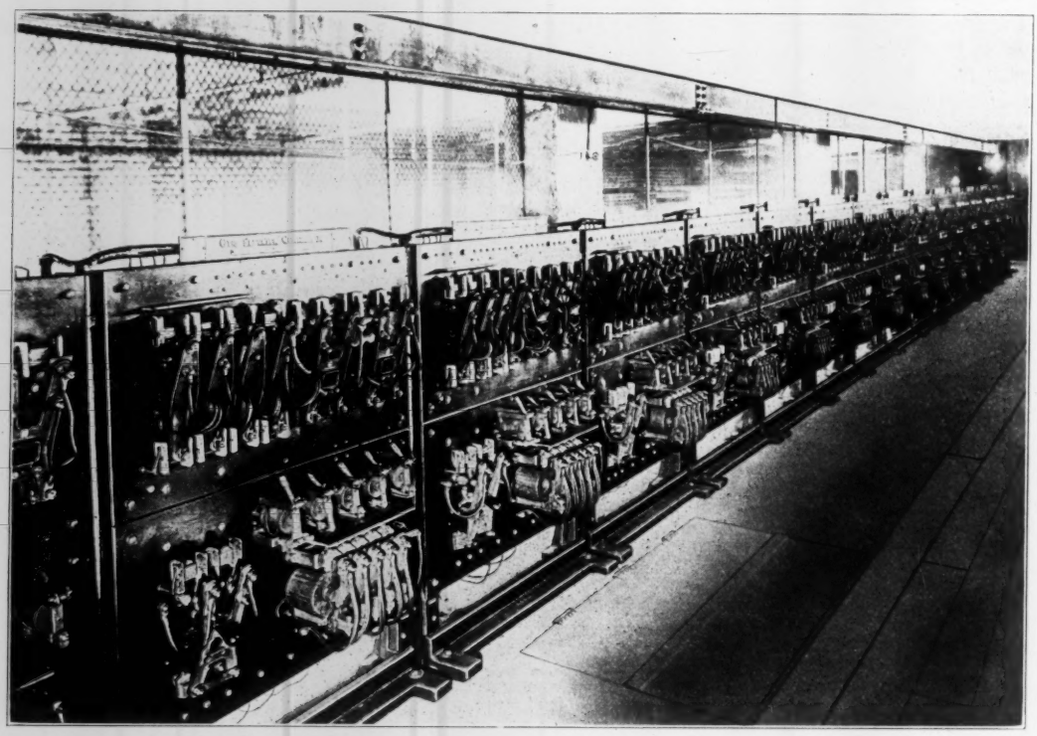


FIG. 16 A LARGE GROUP OF TRACTION ELEVATOR MACHINE CONTROLLERS IN AN OVERHEAD INSTALLATION

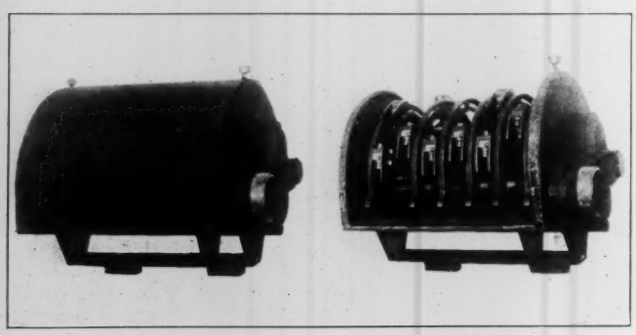


FIG. 17 AUTOMATIC STOPPING SWITCH LOCATED ON CAR

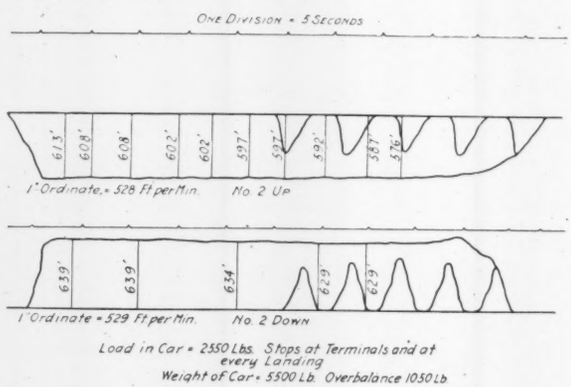


FIG. 18 SPEED CURVE OF HIGH-RISE ELEVATOR IN THE METROPOLITAN LIFE BUILDING TOWER

A number of tests of herring-bone gears (Fig. 22) cut by Falk, Faweus and Otis, have been made, and Fig. 23 shows the results of a series of tests of one particular gear. The difference in efficiency at various speeds is noticeable. This gear has 213 teeth and the pinion 23 teeth, resulting in a gear ratio of 9.27 : 1. A motor speed of 425 r.p.m. gave a car speed of 500 ft. per min. There was quite a difference in the efficiency of the gear at different speeds. The losses included in figuring the efficiency comprised the bearing losses and losses due to the churning of the oil. The difference in the efficiencies at different speeds is due principally to this churning of the oil, the loss from this source being about 1.5 h.p. at a speed corresponding to a car speed of 500 ft. per min. This appears to be quite a considerable loss, when considering that it is a loss due to the lubricant.

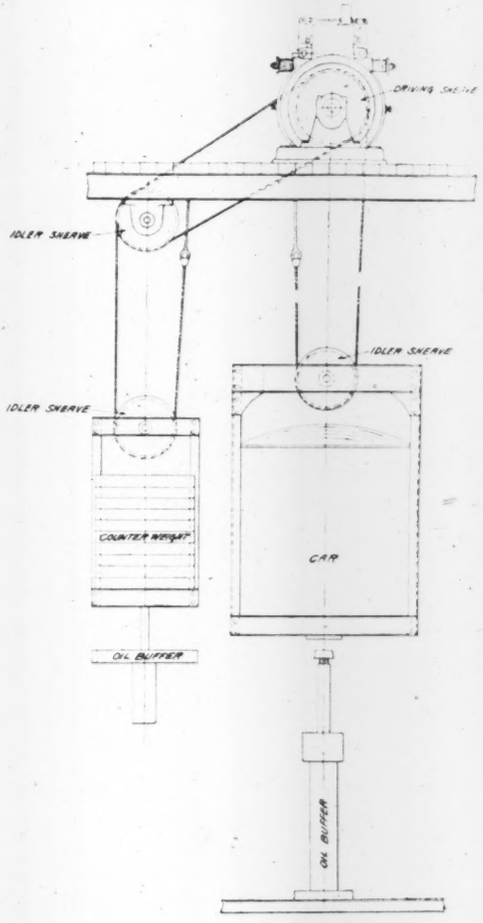


FIG. 19 2:1 ROPING OF A GEARLESS TRACTION ELEVATOR

If the oil is taken out of the gear case and an amount of oil sprayed on sufficient only to prevent cutting, these efficiencies are somewhat increased, particularly for high speed. Under these conditions, the efficiency is practically the same at different speeds; in other words, the efficiency goes quite a little over 90 per cent.

A great number of tests were made also of worm gears with from 1 up to 12 threads on the worm, and with a large variation in the number of teeth in the worm gears. With a 12-thread worm and a 108 tooth worm gear, giving a speed reduction of 9 : 1 or about the same as that of the herring-bone gear, the efficiency was only from 2 to 3 per cent lower, indicating that for high speeds, with comparatively low ratio of reduction, the worm gear is quite efficient. The worm gears with high pitch worms are by no means as inefficient

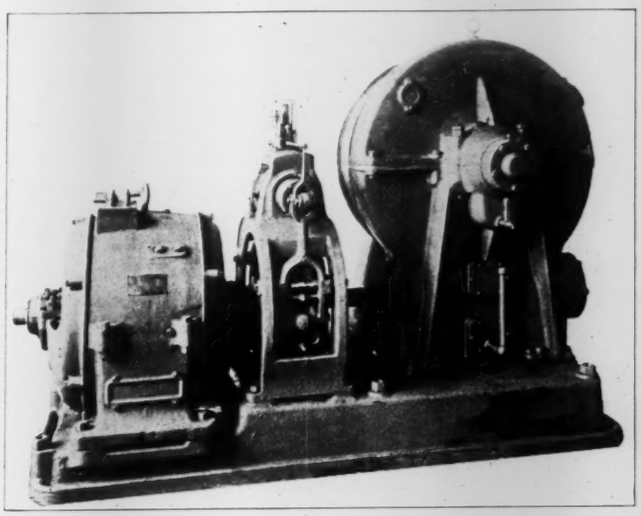


FIG. 20 A GEARED TRACTION ELECTRIC MACHINE USING WORM GEARING

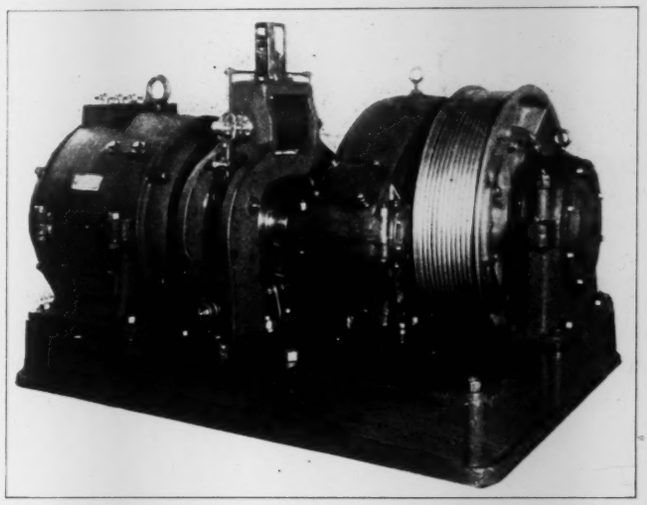


FIG. 21 A GEARED TRACTION ELECTRIC MACHINE WITH HERRING-BONE GEARING

as generally thought. The effect of the oil in this case was practically the same as already mentioned in connection with the herring-bone gear; in other words, at a speed corresponding to 500 ft. per min. car speed, the oil losses were about 1.5 h.p.

Power Consumption. Considerations of power consumption in the machine may be divided into three parts relating respectively to motor efficiency, gear efficiency and inertia:

First. The maximum efficiency of the high speed motor used in connection with the geared machine may occasionally be as high as that of motors used with the gearless, but the efficiency at lighter loads, which is the normal service condition, is lower; hence the high speed motor is at a disadvantage. An equal amount of field regulation may be applied to both high and low speed types of motors.

Second. High speed motor machines may be considered to have, under the best conditions, a gear loss of about 10 per cent, whereas this loss is entirely eliminated in the gearless machine.

Third. Although kinetic energy is the most important factor in power consumption, it has in the past been apparently very little considered. The reason for this is due probably to difficulty in readily determining its amount, in a rather complex elevator machine. A method which is very simple and at the same time quite accurate, will therefore be described.

One of the methods for determining the kinetic energy consists in determining the amount of the inertia of the rotating parts of the elevator by, for instance, the pendulum method, and in ascertaining the mass of the other parts, having straight line motion, by weighing them. This method has a disadvantage in that it cannot be applied to a complete elevator installation. In addition, it is difficult and tedious of execution.

A simpler and more accurate method, not affected by the

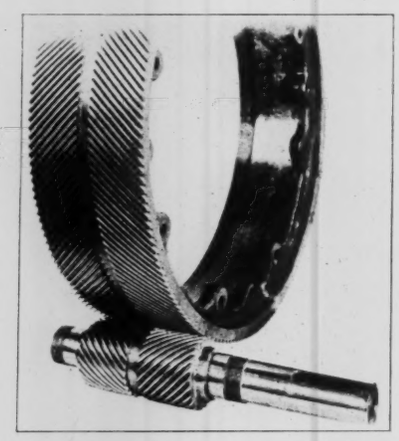


FIG. 22 HERRING-BONE GEAR AND PINION

variation of the coefficient of friction and the windage losses at different speeds, may be explained as follows:

The kinetic energy of a complete elevator system is the sum of the kinetic energies of each of its constituent parts. In general, these parts run at different speeds, but by reducing all forces and masses to a certain speed, say the speed of the elevator car, the problem can be treated as if involving a single body. If the speed in feet per second of this body equals v_1 when the time equals zero, the kinetic energy ($E = 1/2\ m\ v_1^2$) may be expressed by the equation:

$$E = \int_0^T pvdt$$

in which v = the speed at the end of t seconds, p = the retarding force in pounds at the time t, and T = the time in seconds in which the body comes to rest. In this equation pv is the work in foot pounds per second done by the retarding force.

If the rate of work is expressed in watts, we have

$$E = 0.7373 \int_0^T wdt$$

in which w represents the retarding watts at the speed v. It will be noted that the quantity under the integral sign is the area comprised between the retarding watt-time curve and the axis of time.

To obtain the data for this curve, we may assume the object to be the determination of the kinetic energy of a complete elevator installation at the time when the elevator car has attained the speed v_1. Preferably, the load on the car side of the driving sheave should equal and balance that on the counterweight side. This can be accurately effected, without weighing, by merely taking watt-meter readings for up and down travel at equal speeds, adjusting the load in the car until the up and down readings are equal, indicating that both sides are balanced.

The car is then run at the speed v, when the armature current (but not the field current) is interrupted, so that the system may come to rest retarded by the mechanical friction, windage and core losses of the motor. The indicated work in watts due to friction, windage and core losses is then equal to the retarding watts w in the above equation. The speed and time are also observed and a graph of the speed-time curve is drawn.

Next, the motor is connected to the line, the elevator run at different speeds, and the watts input observed for each speed. If the I^2R losses represent the losses in the armature winding of a direct current motor and W, the observed watts

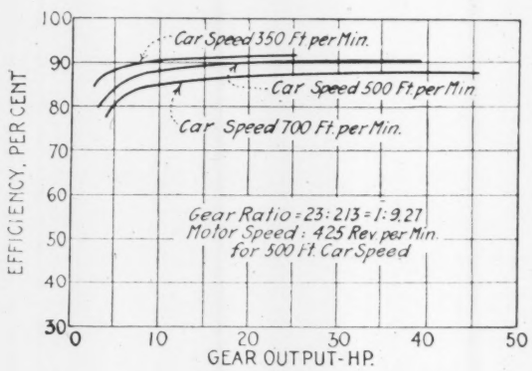


FIG. 23 RESULTS OF EFFICIENCY TEST OF A HERRING-BONE GEAR

required to run the elevator at the speed v, evidently then $W - I^2R$ gives the watts necessary to overcome the friction, windage and core losses. Consequently, $W - I^2R$ at the speed v, is equal to the retarding watts w at that speed.

The second series of observations, therefore, provide the data for the graph of the retarding watts-speed curve. Having thus obtained the graphs of the speed-time curve and of the retarding watt-speed curve, it is a simple matter to construct the retarding watt-time curve. The quantity W may then be obtained by means of a planimeter and, with the aid of the above equation, the kinetic energy at speed v_1 may readily be calculated.

The retarding watt-time curve is so nearly a parabola that only an inappreciable error results from considering the curve as such. Instead of obtaining the area representing wdt by means of a planimeter, it is sufficient to employ the equation of a parabola, whereby this area is found to be one-third of the product w_1T; w being equal to w_1 when the speed $v = v_1$ which occurs when $t = o$.

When, therefore, extreme accuracy in the determination of the kinetic energy is not required, it is sufficient to obtain merely two observations or readings; one being the time T in seconds in which the elevator comes to rest after the armature current is interrupted at the speed v_1, and the second

being w_1 in watts, which is equal to the watt-input W required to run the elevator at the speed v_1 minus the I^2R losses.

If it is required to determine the kinetic energy of the hoisting machine only, the car and counterweight may be blocked, and the tests made as before. By removing from the machine part after part, and making tests after each removal, the kinetic energy of each of the various moving parts may be obtained.

It will be noted that the method outlined above refers to direct current machines; however, with necessary modifications in regard to the determination of w, the retarding watts, this method may be applied to alternating current machines also.

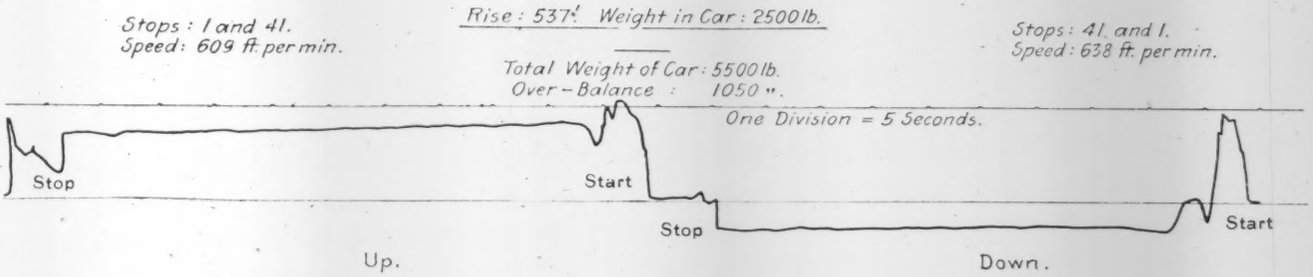


FIG. 24 POWER CONSUMPTION CURVES OF A TRACTION ELEVATOR MACHINE IN THE METROPOLITAN LIFE BUILDING TOWER

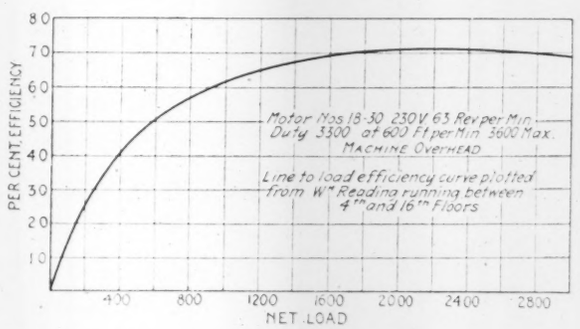

PER CENT. EFFICIENCY
Motor Nos. 18-30 230 V. 63 Rev. per Min.
Duty 3300 at 600 Ft. per Min. 3600 Max.
MACHINE OVERHEAD
Line to load efficiency curve plotted from Wm Reading running between 4th and 16th Floors
NET LOAD

FIG. 25 EFFICIENCY OF COMPLETE GEARLESS TRACTION ELEVATOR INSTALLATION—NEW YORK TELEPHONE BUILDING

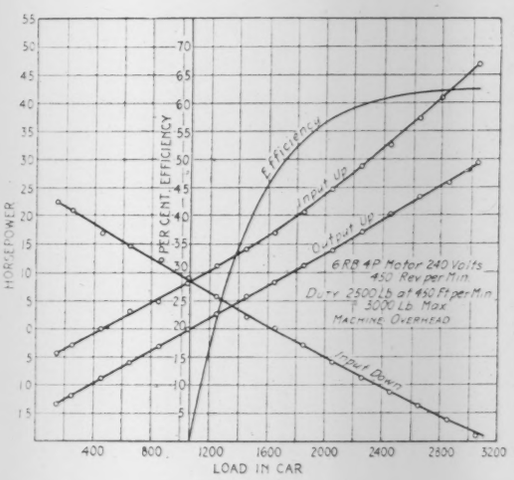


FIG. 26 EFFICIENCY OF COMPLETE HERRING-BONE GEAR TRACTION ELEVATOR INSTALLATION—YALE CLUB BUILDING

An idea of the relatively high cost of operation of electric elevators, utilizing high speed motors with gears, may be gained by means of the following example: Assume a weight of 1 lb. revolving at a radius of 9 in. at 800 r.p.m. (which is the speed usual with motors for worm gear machines). The kinetic energy to be imparted to this weight each time it is started from rest and brought to full speed will then be 61.3 ft.-lb.

If the elevator starts on an average of 4500 times per day and runs three hundred days per year, the cost of the energy absorbed for acceleration, at 4 cents per kw-hr. would amount to $1.25 per lb. per year. If, instead of one lb., the weight were 219 lb. (which is the effective equivalent weight of a particular herring-bone gear machine), the cost would be $273.00 per year.

Of course, part of the kinetic energy required for starting is returned at the time of stopping, but on the other hand the starting efficiency is low, since a large amount of the power is lost in the starting resistance and some in the motor. The loss in the starting resistance and motor is certainly larger than the energy recovered at the stop, and hence the cost per year for accelerating and retarding 219 lb. of weight, under the above conditions, would amount to more than $273.00.

In ordinary passenger service the load taken up and distributed to the various floors of the building is practically the same as the load brought down to the starting point, therefore, the electric power consumed is not primarily power required for the transportation of passengers, but is the work required to overcome friction and to supply the kinetic energy for each start, less the amount that is recovered at the stop. The friction losses are by far the smaller of the two. Therefore, a comparison of the kinetic energies of two elevators, for the same service and with the same method of control, gives a good indication of what their relative power consumption and rapidity of acceleration will be in actual service.

In the following tabulation are given the kinetic energies of two traction machines, one with herring-bone gear and the other gearless, both built for a car speed of 600 ft. per min., and for the same load. The herring-bone gear machine had a motor running at 505 r.p.m., a pinion with 23 teeth, gear with 213 teeth, and driving sheave 42 in. in diameter. The gearless machine had a motor running at 63.6 r.p.m. and a 36 in. driving sheave.

		Kinetic energy in ft.-lb.	
Herring-bone gear machine	motor armature	7,420	
	brake pulley	2,920	
	driving sheave	1,000	
	herring-bone gear	2,060	
	Total	13,400	
Gearless machine	Armature, brake pulley, driving sheave	Total	2,450

It will be noted that the kinetic energy per start of the herring-bone machine would be about 5.5 times that of the 1:1 gearless machine. Consequently, if the cost of power for accelerating and retarding the 13,400 ft.-lb. of the former amounted to $273.00 per year, the cost for the gearless machine would be but $\frac{\$273}{5.5}$ or $50.00.

It may not be at once apparent why the high speed motor with armature of much smaller dimensions, although running

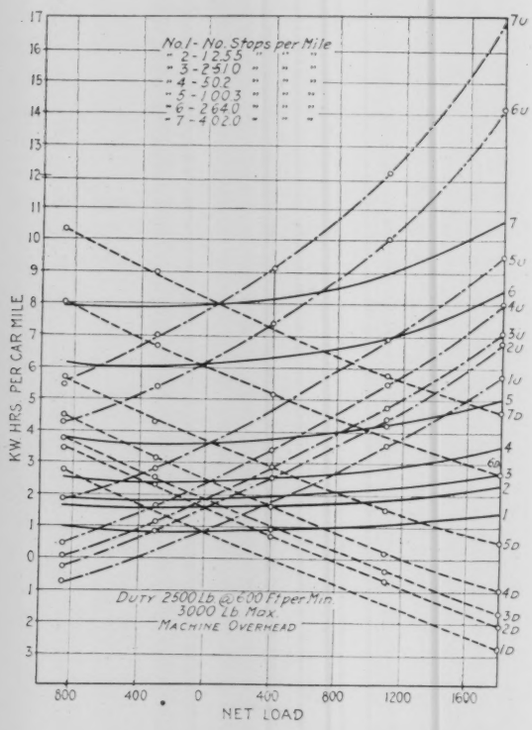


FIG. 27 POWER CONSUMPTION TEST OF A TRACTION ELEVATOR MACHINE IN THE ADAMS EXPRESS CO. BUILDING

at high speed, should have such high kinetic energy, compared with that of a slow speed armature of much heavier weight and larger dimensions. A simple example may be given illustrating this fact.

Take a motor of certain construction and field strength, and assume that on a 220 volt circuit it will develop 10 h.p. and run at 100 r.p.m. On a 440 volt circuit, this same motor with equal armature current and with shunt field arranged to maintain the same field strength, will develop 20 h.p. and run at 200 r.p.m. That is, the voltage being doubled, the horsepower and speed will be doubled; and, the kinetic energy, varying as the square of the speed, will be quadrupled. If then, we assume the kinetic energy in the first case to be 500 ft.-lb. that in the latter case will be 2000 ft.-lb., and the kinetic energy per horsepower of the motor running at 100 r.p.m. will be $\frac{500}{10}$ or 50 ft.-lb., and that of the motor running at 200 r.p.m. will be $\frac{2000}{20}$ or 100 ft.-lb. In other words, in this example, doubling the speed will double the kinetic energy per horsepower output.

As already indicated, the kinetic energy of a complete herring-bone gear machine was approximately 5.5 times the kinetic energy of the gearless. This increase is not directly proportional to the speeds of their respective motors because the ratio between the kinetic energies of the driving sheave, brake and gear coupled to the motors, is considerably less than proportionate to the motor speeds. If, however, the

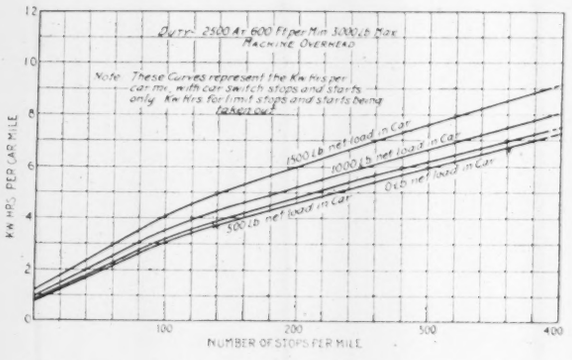

Duty 2500 At 600 Ft per Min 3000 Lb Max
Machine Overhead
Note These Curves represent the Kw Hrs per
Car Mi. with car switch stops and starts
only Kw Hrs for limit stops and starts being
taken out
1500 Lb net load in Car
1000 Lb net load in Car
500 Lb net load in Car
0 Lb net load in Car
KW HRS PER CAR MILE
NUMBER OF STOPS PER MILE

FIG. 28 AVERAGE POWER CONSUMPTION FOR VARIOUS LOADS AND NUMBERS OF STARTS—EXPRESS SERVICE—ADAMS EXPRESS BUILDING

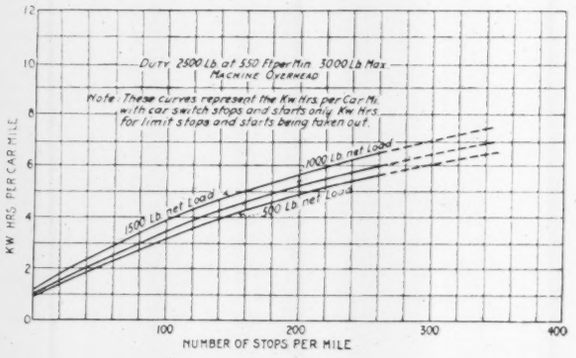

Duty 2500 Lb at 550 Ft per Min 3000 Lb Max
Machine Overhead
Note These curves represent the Kw Hrs per Car Mi.
with car switch stops and starts only Kw Hrs
for limit stops and starts being taken out
1000 Lb net Load
1500 Lb net Load
500 Lb net Load
KW HRS PER CAR MILE
NUMBER OF STOPS PER MILE

FIG. 29 AVERAGE POWER CONSUMPTION FOR VARIOUS LOADS AND NUMBERS OF STARTS—LOCAL SERVICE—ADAMS EXPRESS BUILDING

armatures only are considered, the fact would be disclosed that in this case the kinetic energy is more than proportional to the speed because, on account of the gear losses, the geared machine requires a motor of greater capacity than does the gearless machine.

At this point, it may be interesting to observe the efficiencies and power consumption of some actual installations. The curves in Fig. 24 show recording wattmeter readings taken in the Metropolitan Life Tower of an elevator carrying a load of 2500 lb. up and down. The upper curve indicates the watts taken when lifting the load and the lower curve the watts required for starting, and the watts generated back into the line, when the load is descending.

The curve in Fig. 25 shows the efficiency of a complete installation of a gearless traction elevator in the New York Telephone building, at Walker and Lispenard Sts., New York. It may be noted that the maximum efficiency from line to load, allowing for all losses, is over 71 per cent. The curve in Fig. 26 shows the efficiency of a complete elevator installation of a herring-bone gear machine in the new Yale Club building in New York City. It may be noted that the maximum efficiency from line to load is about 62 per cent.

The curves in Fig. 27 show the results of recording wattmeter readings taken at the Adams Express Company's building, New York City. The loads indicated are net loads; that is, loads representing the unbalanced difference between weights on the car side and weights on the counterweight side of the driving sheave; and the ordinate at zero indicates the balanced condition of these weights. The broken curves, ascending from left to right, represent power consumption while lifting unbalanced weights. The broken curves, descending from left to right, represent power consumption while lowering unbalanced weights. The full line curves, drawn between the former, represent the average power consumption required for lifting and lowering weights. Curves are shown for various numbers of stops per car mile, ranging from no stops to 402.

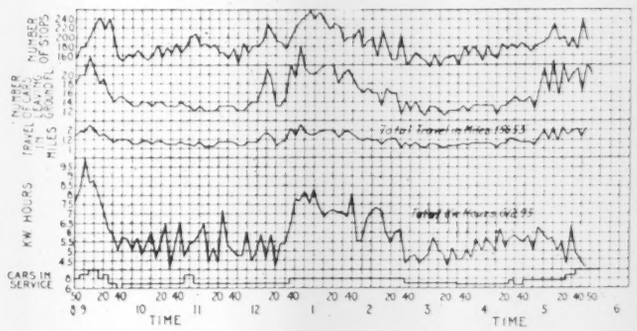


FIG. 30 EXPRESS SERVICE

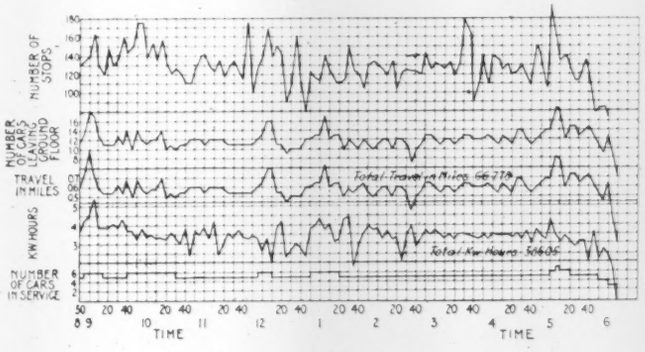


FIG. 31 LOCAL SERVICE

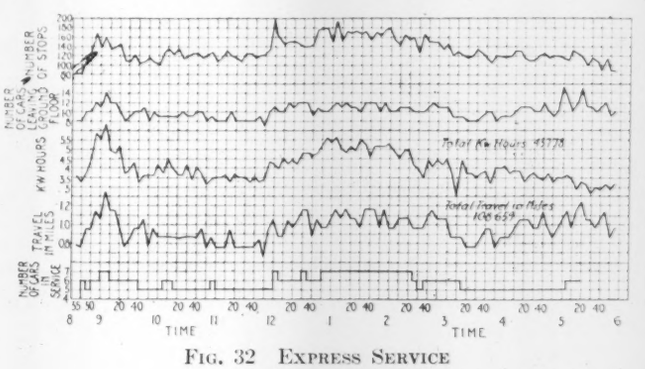


FIG. 32 EXPRESS SERVICE

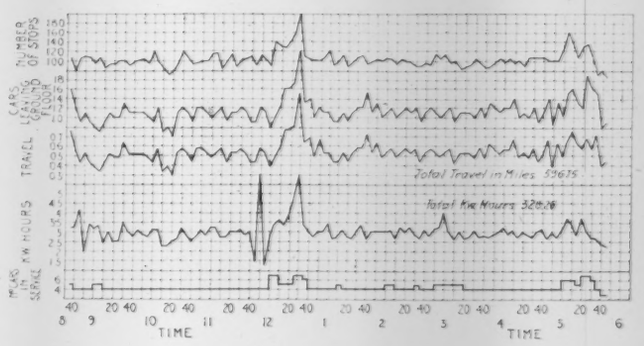


FIG. 33 LOCAL SERVICE

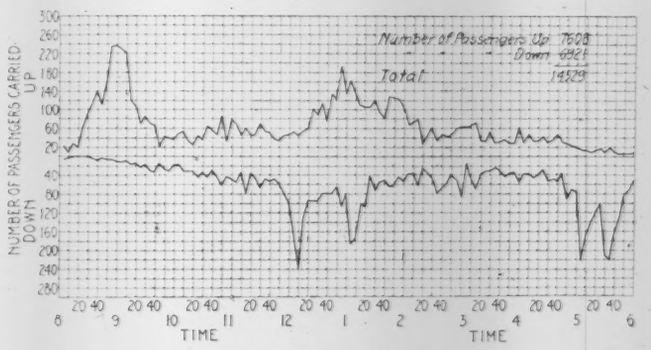


FIG. 34 EXPRESS SERVICE

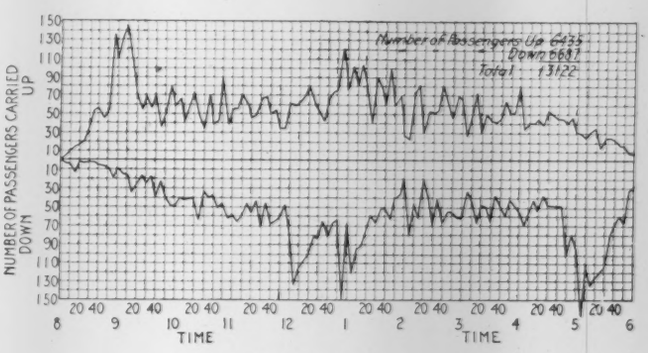


FIG. 35 LOCAL SERVICE

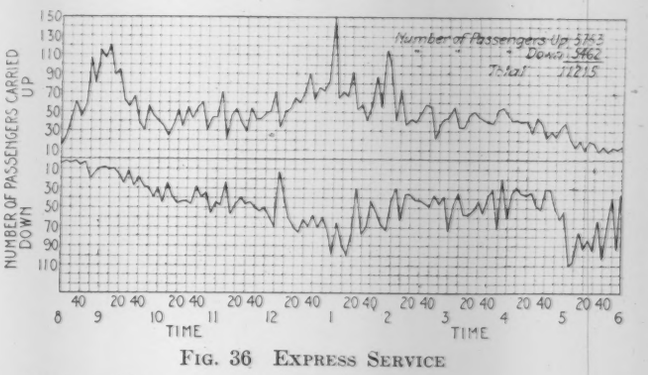


FIG. 36 EXPRESS SERVICE

CHARTS OF ELEVATOR SERVICE AT THE HUDSON TERMINAL BUILDINGS

The average amounts of power consumption, for various loads and numbers of starts, are plotted in curves shown in Figs. 28 and 29. These curves indicate the increase in power consumption occasioned by an increase in number of starts while transporting various loads, Fig. 28 representing express and Fig. 29 local service. By referring to curve 2 in Fig. 28, it may be noted, that with a net or unbalanced load on the car side of the driving sheave of 500 lb., the power consumption would be 0.8 kw. per car mile when no stops whatever are made, and about 3.2 kw. when there are 100 stops. The net load of 500 lb. represents a load in car amounting to 1500 lb. partly balanced by a 1000 lb. counterweight. By comparing the curves one with another, it may be noted that the power consumption increases with the number of starts to a greater extent than with a corresponding increase in net load. Comparison between curves in Figs. 28 and 29 will indicate that the power consumption for equal

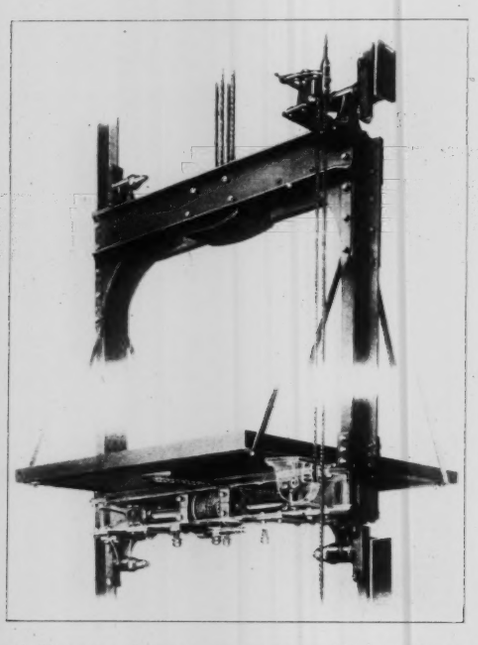


FIG. 37 A TYPICAL APPLICATION OF THE WEDGE-CLAMP SAFETY

loads and number of starts, is greater for the express service than for the local service, due to higher speed and greater masses.

A number of observations have been made of the actual service conditions encountered in different buildings. Some of the most interesting are those of the Hudson Terminal Building in New York City, where the service conditions are usually severe and varied. The curves in Figs. 30 to 33 record these conditions, indicating the number of cars in service, the power consumption in kilowatt hours, the miles traveled, the number of cars leaving the ground floor, the number of stops, etc., during hours from 8 a.m. to nearly 6 p.m. Both express and local service for certain groups of elevators at the 30 Church St. and the 50 Church St. buildings are represented.

The curves in Figs. 34 to 36 record the movement of passengers during different hours of the day; the upper curves showing the number of passengers carried up and the lower curves, the number carried down. These curves well illustrate the tremendous inrush and exodus of passengers during short periods of time, morning, noon and evening; as well as the normal traffic between times.

The curves in Fig. 36 illustrate the most severe "rush-hour" service encountered. It may be observed that at about 8.30 in the morning, there is a tremendous inrush for about twenty minutes, which tapers off to a slight rush later on; around ten o'clock, or half-way between the rush hours, there is about the same amount of service in both directions. Then just at twelve o'clock, sharp, there is a tremendous rush outward, which is all over in ten minutes. In other words, all these passengers have had to be taken out of the building in ten minutes, the same number being handled, from 12.20 on, during the inrush which, however, lasts for about twenty minutes. Then, during the afternoon, may be noted the continuation of traffic up and down, in about equal amounts. The promptness with which the people leave the building at night may be observed by referring to the curve in Fig. 36.

These charts show service conditions, indicating what tremendous variations of traffic are encountered in elevator service. In order to prevent congestion in a building the elevators must be capable of taking care of at least half, or say about two-thirds, of all the people in a building during practically only ten minutes. They indicate further how necessary it is to be able to maintain high speeds during rush hours. At such times, when the elevators have to carry all the people up, speed is an important factor. In this respect, the electric traction elevator has the advantage over the hydraulic elevator, in that it is capable of maintaining constant speed independently of the load, whereas the hydraulic elevator varies its speed with variations in load. In other words, during the time of maximum service, with fully loaded car, the hydraulic elevator runs at its minimum speed, whereas with light loads, when speed is not important, the speed is maximum. Undoubtedly, this indicates one of the principal reasons why the electric has gradually, and now almost entirely, supplanted the hydraulic elevator.

Electro-Mechanical Elevator Safety. In conclusion, mention may be made of various elevator car safeties, with particular reference to a new safety that has lately been put on the market. The essential requirement of an elevator car safety is to stop and hold an elevator car under all conditions of load and speed, whether the hoisting ropes are intact or parted. Fig. 37 illustrates the safety device usually employed until a comparatively short time ago; and which, even at the present time, is still installed. It is the standard so-called wedge clamp safety, which clamps the rails for retarding and holding the elevator car in case of overspeed or free fall.

The present practice utilizes the same principle of application whether the safety is actuated under conditions of excessive speed with hoisting ropes intact or during free falling. A very strong retarding force is required to stop a free falling car, but this strong retarding force if applied with ropes intact is excessive and will give an unpleasant shock to the passengers.

This is obvious when an actual installation is analyzed. Th car, with all attachments, of a modern high rise elevator, weighs about 6500 lb., the maximum load is usually 3000 lb. and the compensating ropes weigh about 2500 lb.; the total load to be stopped by the safety with the ropes parted would therefore be 12,000 lb. To insure the stopping of a car, at

least 50 per cent excess force should be provided, bringing the total retarding force required, up to a minimum of 18,000 lb. Were a major portion of this retarding force applied with the ropes intact, the car would be stopped too abruptly. This would be accentuated with a light load, particularly as the machine brake and strong dynamic action of the motor assist the retarding force of the safety.

For the above mentioned reasons, it is essential, therefore, that the safety should apply a *strong retarding* force in case of a free falling car with ropes parted, and a *light retarding* force in case of overspeed with ropes intact. The principal safety features which should be incorporated in an elevator safety for high speed elevators are as follows:

a The safety should be so arranged that the application of a predetermined and definite *light retarding* force will stop the car and net load without shock in case of overspeed with hoisting ropes intact.

b The safety device should be so arranged that the application of a predetermined and definite *strong retarding* force will gradually bring the car and maximum load to rest in case of a free falling car.

c The *light retarding* force should be immediately applied, preferably by means of a centrifugal governor, in case the car should attain excessive speed in either direction.

d It should be possible to apply immediately the *light retarding* force from within the car, when desired.

e The *light retarding* force should be applied automatically in case of overrun at the upper or lower terminals, and yet be so arranged as not to interfere with the starting of the car in the opposite direction.

f The *strong retarding* force should start to apply the instant the hoisting ropes part, independently of the speed of car and counterweight.

g A tripping governor should not be necessary to apply the *strong retarding* force, except on safe lift machines.

h In the case of safelift machines, a *strong retarding* force should be automatically applied independently of the parting of the hoisting ropes, at a definite speed which should be higher than the speed at which the *light retarding force* is applied.

i The releasing carrier, even when improperly adjusted, should not prevent the application of a *strong retarding* force to the car in case the ropes part.

j The principal actuating parts of the safety should be made to move automatically at frequent intervals, in order to prevent them from clogging up or corroding together; this motion of the actuating parts need be only very small, to give the desired results, but some motion is necessary to secure dependable action of the safety.

Figs. 38 and 39 show the general features of an electro-mechanical elevator car safety which embodies all of the above described requirements. The *light retarding* force is obtained by means of a helical steel spring forcing the wedges between the rollers of the safety jaws. When the car is in service this spring is held under compression by means of an electro-magnet. The instant the current in this magnet is interrupted, either by the centrifugal governor, safety switch in car or limit switches in the hatchway operated by the car or counterweight, the *light retarding* force is applied.

The *strong retarding* force is obtained by revolving the safety drum, thereby actuating the right and left hand screw, which in turn moves the wedges and forces the jaws against the guide rails. The *strong retarding* force is definitely determined by the number of turns around the safety drum, which vary in number according to the maximum load and the amount of the safety rope tension weight.

The releasing carrier is placed on the counterweight and will therefore apply the *strong retarding* force of the car safety, even though the releasing carrier fails to release, due to faulty adjustment. The *strong retarding* force only is applied to the counterweight safety.

Whenever the current is cut off from the elevator, the electrical parts of the safety are operated, thereby applying the *light retarding* force. The mechanical actuating parts of the safety effecting the *strong retarding* force are continually kept in slight motion when the elevator is in operation, due to the different stretching of the hoist and governor

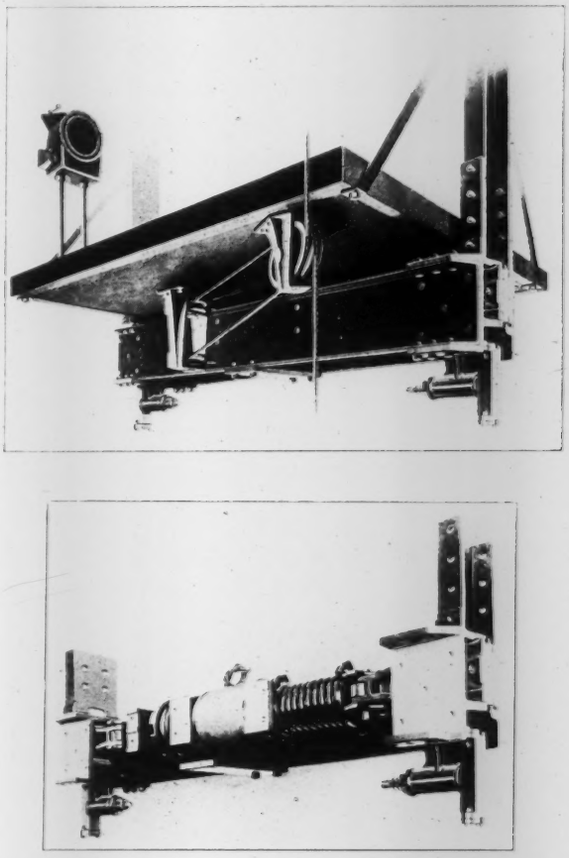


FIG. 38 DETAIL VIEWS OF AN ELECTRO-MECHANICAL SAFETY AS APPLIED TO A CAR

ropes. It is possible to remove all parts without disturbing the car platform, enclosure or car frame, thereby assuring easy access for inspection. In case of safelift elevators, a *strong retarding* force as described in paragraph *h* is applied by means of a parallel jaw double acting governor.

An electro-mechanical safety device such as just described has been designed and built by the Otis Elevator Company and subjected to a long series of experimental tests, the results obtained being remarkably successful. Some forty-nine elevators in the new Equitable Building have been equipped with these safeties and the consulting engineers, the builders and the New York Building Department have thoroughly and exhaustively tested them with entire and complete satisfaction to all concerned.

DISCUSSION

REGINALD P. BOLTON called attention to the remarkable development in the electric elevator, which now stands far and away at the head of all other types, and suggested that this meeting may be adequately described as the funeral service of the plunger elevator. He stated that there are 4,000 of the old hydraulic elevators still in service in New York, and referred to a scheme which Mr. Charles R. Pratt has developed for utilizing certain details of the hydraulic equipment in connection with electrical machines, instead of discarding the old hydraulic equipment entirely.

Mr. Bolton stated that the construction of the elevator all stages of repair, and finally they will wear beyond repair and must go out, but many of them are still good for many years more. In looking into the matter in the last few months he found the problem to be as follows:

To change over to an electric elevator, one has to charge off 10 per cent to depreciation, and if the initial cost runs up, as it does some times, to $4,000, $6,000 or $8,000 in an electric elevator, and if the owner charges off that 10 per cent depreciation, it wipes off the difference in saving in cost per car mile. He stated that it requires only a glance at any graphic recording wattmeter curve of kilowatt-hours per car mile to show that about 75 per cent of the power load on an electric elevator is inertia and not gravity. Modern electric

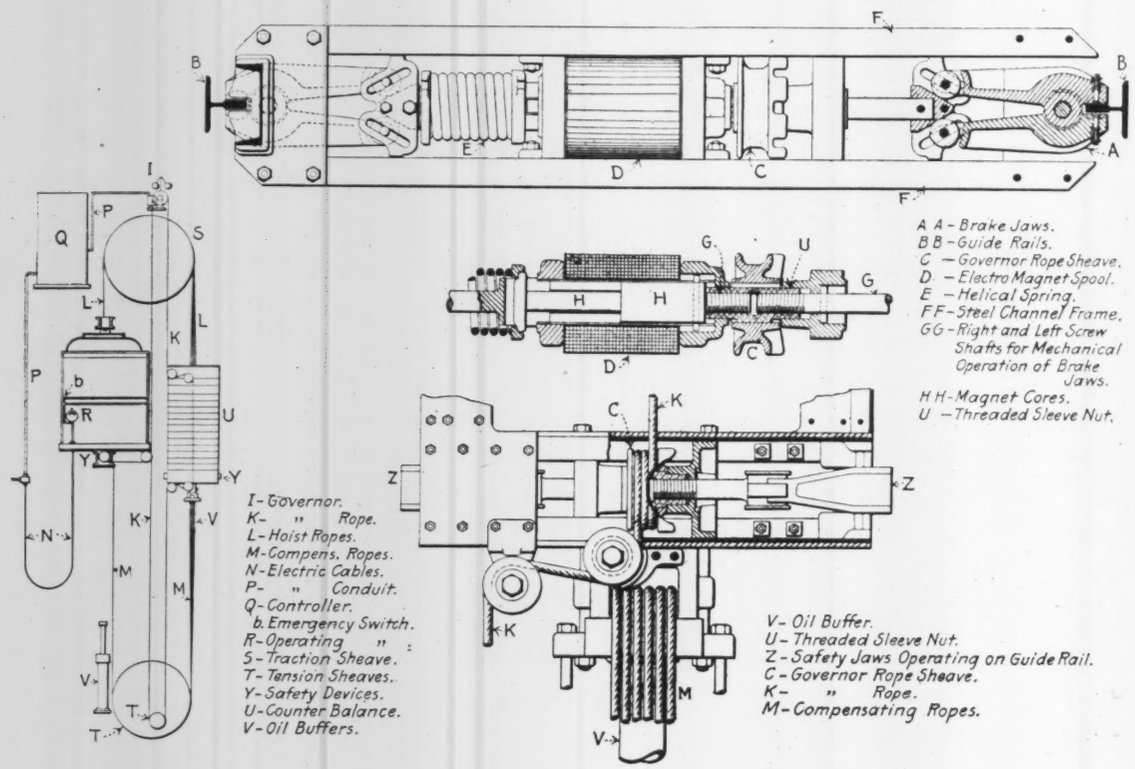

A A - Brake Jaws.
B B - Guide Rails.
C - Governor Rope Sheave.
D - Electro Magnet Spool.
E - Helical Spring.
F F - Steel Channel Frame.
G G - Right and Left Screw Shafts for Mechanical Operation of Brake Jaws.
H H - Magnet Cores.
U - Threaded Sleeve Nut.
I - Governor.
K - " Rope.
L - Hoist Ropes.
M - Compens. Ropes.
N - Electric Cables.
P - " Conduit.
Q - Controller.
b. Emergency Switch.
R - Operating " :
S - Traction Sheave.
T - Tension Sheaves.
Y - Safety Devices.
U - Counter Balance.
V - Oil Buffers.
V - Oil Buffer.
U - Threaded Sleeve Nut.
Z - Safety Jaws Operating on Guide Rail.
C - Governor Rope Sheave.
K - " Rope.
M - Compensating Ropes.

FIG. 39 CONSTRUCTIONAL DETAILS OF THE WEDGE-CLAMP SAFETY, ELECTRO-MECHANICALLY OPERATED

and the facilities with which it is provided cover only one half of the work which the elevator accomplishes, the other half of the time in which the elevator is in operation being devoted to the operations of loading and unloading passengers; he felt that considerable opportunity remains for improving elevator operation, and referred to such elements as the operator, his position in the car, starting and stopping the car, the control of doors and gates, systems of signaling, and the handling of passengers.

Mr. Bolton also discussed at length the difficult problems of passenger traffic in the elevators of the large New York City buildings, and quoted from his observations as to traffic peculiarities in other cities as well, and their effect upon the elevator service.

CHARLES R. PRATT called attention to the fact that there are still some 4,000 of the old hydraulic elevators in use in New York City, costing two or three times as much per car mile as the modern electric elevator would cost. They are in elevators regenerate gravity to a very limited extent and inertia not at all; on the contrary, by the expedience of an armature shunt across the line, they take power to stop the load.

Hydraulic transmissions with a variable stroke pump for each elevator, a group of pumps driven by one power unit, offers, Mr. Pratt suggested, a practical regeneration of this inertia energy, but there appears to be no such pump as yet produced to meet all the requirements of this service, although experiments in this have been undertaken. Continuously revolving field or armature electric elevators offer somewhat the same regeneration of energy as the hydraulic transmission, but have not yet been proved to fill the bill.

He pointed out that if the inertia load on electric elevators could be balanced like the piston in a vertical cylinder engine, the kilowatt-hours per car mile could be reduced to about one-fourth the amount now expended. Hydraulic, mechanical, electric and flywheel action offer an inertia balance, but an underbalanced car cuts at the source by reducing

the mass and eliminating all inertia power load on the down trip.

Taking more than twice the maximum net gravity load appears at first thought to be wasted energy, he said, but when it is considered that high-duty hydraulic elevators and the Sprague-Pratt electric elevators, with their mechanical friction losses and no regeneration circuit, take about the same kilowatt-hours per car mile as the average modern electric elevator, the possibilities of high efficiency in underbalanced cars becomes worthy of serious attention.

The advantages, considered in detail, are:

a Always driven by gravity on the down trip.

b Controlled by armature resistance only, giving all ranges of speed, power circuit up and dynamic circuit down, using no armature shunt across the line to waste power at slow speeds and in stopping.

c By use of an automatic potential switch it regenerates efficiently at full speed down, returning a large percentage of the power used on the up trip.

d Reduces starting current on up runs by having less mass to accelerate.

e No starting or running current used on down trip.

f Requires but one field strength for all speeds, reducing size of motor.

If this be applied to a highly efficient modern electric elevator motor, either direct coupled or driven by helical or steep pitch worm gearing, Mr. Pratt stated the results would be interesting. In replacing old hydraulic with new electric elevators, and using an overbalanced car with a back drum counterweight or traction rope drive, all old hydraulic sheaves, overhead beams, counterweights, guides, vertical cylinders, etc., have to be altered, removed and scrapped, new parts substituted, and the entire hoistway brought up to date according to the Building Code laws. Whereas, by use of the underbalanced car, using the entire old hydraulic hoistway equipment undisturbed, even using the vertical cylinder for a continuous safety with a speed regulating valve in the circulating pipe, for water, oil or air, about one-half the total cost of the change over from hydraulic to electric is saved, with practically no interruption to the elevator service. Also a net profit is shown to the owner after he charges off 10 per cent of the initial cost against the amount saved in power and operating expenses.

There are four thousand old hydraulic elevators in New York City and ten times that number outside, waiting for a system that will finance the change to electric drive. Fig. 40 illustrates such a system applied to an old Otis machine. Two more grooves are added to the winding sheave, when the electric machine is located below with a regulating valve placed in the circulating pipe, using either air, oil or water. In the case of excess speed, this balanced piston operates to choke off the circulating pipe, and gives in effect very good safety. The control is very simple. All the magnets are down on the dynamic circuit. When the generated voltage equals or exceeds the line voltage, the potential switch is thrown over, and return is had for what it costs one to hoist.

ANDREW M. COYLE took exception to the statement by Mr. Lindquist in reference to the relative efficiences of the direct driven traction machine and the gear driven machine. While no one doubts that for light duty and high speed the direct driven machine is more efficient, there is an immense field in which the geared machine is highly efficient and in which the direct driven machine cannot be used at all. It is, therefore, he stated, not altogether fair to make the comparison based on a car speed of 600 ft. per minute. The geared machine using herring-bone or helical gears is highly efficient for all duties and speeds from 200 to 400 ft. per minute and this service covers the great bulk of elevator installations. He has been connected with the design and installation of several elevator machines using helical gears and has found that the gears were highly efficient and in every way satisfactory.

Mr. Coyle also took exception to the statement that these gears are only slightly more efficient than worm gearing. His reasons were stated as follows:

A worm gear is a special application of the wedge. The

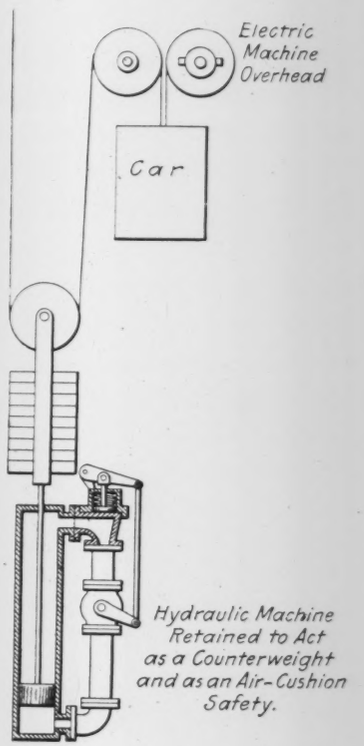


FIG. 40 A METHOD OF APPLICATION OF ELECTRIC MACHINES TO OLD HYDRAULIC ELEVATORS

load moved is carried forward upon an inclined plane. The load which can be carried upon a single gear is limited. The working surfaces have only line contact, and when the load is enough to force the lubricant from this line, abrasion immediately sets in. To overcome this difficulty, the tandem worm gearing has been designed. By this arrangement the load is divided between two gears and the line of contact thereby increased.

It is obvious that, within limits, the steeper the incline, the higher the efficiency of the gear. The shorter the distance the load has to slide, the less will be the loss by friction. For this reason gears of high pitch angles give better results.

Worm gears doing heavy or continuous service, must be completely submerged in oil. A certain percentage of the power is expended in churning the oil. The power thus expended is constant for any given gear. When the load is

light, the power expended represents a considerable percentage of the whole work. On the other hand, when loads are light, the surface lubrication is better, and better results are obtained in the thrust bearings.

The *herring-bone* or *helical gear* is the most efficient gearing so far developed for elevator or any other service. These gears when properly cut are practically noiseless. The slight tendency to wear, is at the points of the teeth and tends to throw the load toward the pitch line where sliding friction is least. The helical gear works best when thoroughly lubricated; but it is a mistake to submerge the pinion. The very slight clearance allowed in these gears causes the oil to be confined in the teeth in such manner as to offer great resistance. It is best to use moderately light oil and to give the teeth a chance to drain before coming into mesh.

The efficiency of the worm gear is limited by the fact that the load must slide from five to ten times the distance it is lifted and that it is entirely dependent upon lubrication. In the case of the helical gear the sliding friction is almost negligible; the gears do not wear and cause back lash as is the case with the worm gears and the lines of contact and the strength of the teeth may be made sufficient to take care of any desired load.

An elevator machine using worm gearing, assumes an outline which lends itself readily to installation in buildings and for this reason as well as on account of low cost this type of machine is in some cases to be recommended. In point of efficiency the helical gear is entirely preferable.

ROBERT JOHNSON called attention to a condition frequently met with that has not been touched on at all in the paper, namely, the use of alternating-current in connection with elevator operation. The conditions referred to would, he said, hardly apply to an installation of alternating-current machines with regard to reliability or speed, and also as to the application of the brake gradually and slowly. This, he said, was a very important point, and he thought it would be very interesting to know whether alternating current is entirely successful in connection with high speed elevators, particularly in view of the fact that in certain parts of New York City alternating electric current is the only type of current which is available.

M. WM. EHRLICH, referring to the question of safeties supplied for the protection of elevators, said that while, of course, the standard safety devices usually installed in connection with an elevator become a good precaution, the records of the building departments and also of the different insurance companies, show that the elevator accidents from breakages of ropes or other parts of the apparatus are very small, the more recent statistics showing that about 80 per cent of the deaths in elevator accidents were caused by open or unlocked gates, or negligence in the operation of the gates by the elevator operator. The way to prevent that, he said, was to use a safety or automatic lock, which will necessitate the elevator making a full stop, and so arranged that before leaving the floor, the gate must be positively closed. That, he said, would prevent accidents caused by open doors and gates. A short time ago he had occasion to test an electro-mechanical device of that nature, and found that under actual service conditions the additional time consumed was ¼ second per trip, or only 8 seconds being lost in an average office building of 32 trips an hour.

Referring to the power consumption diagrams presented by the author, he pointed out that all these charts are, from the point of view of service, of paramount importance, and he therefore suggested that the values of stops per car-mile be converted to a more applicable basis as related to buildings; that is, instead of the unit of "stops per mile," these be changed to a unit of so many stops per number of floors.

Where in railroad service all stops are usually predetermined, he said, the first basis is serviceable, but in passenger elevator practice, where the installations occur in buildings of not only different total heights but varying story heights, and where the stops correspond to the demand of the passenger traffic at different parts of the day, it has been found by extensive observation that a unit ratio in which the number of stops are related to ten floors of travel, is the most expedient unit. Exhaustive studies of passenger elevator traffic have established the ratio of 4 to 10, a unit representing four stops in ten floors, as the average travel conditions in office buildings. Thus the observed number of stops in this class of building becomes the measure of proper division of the service when related to the unit of 4:10, which is the most economic point of operation, meaning, of course, current consumption.

Mr. Ehrlich asked that Mr. Lindquist supply the data to enable one to convert the stops per mile into the number of stops in ten floors. This would mean giving the height of elevator travel in feet and the number of floors served by the different cars. To illustrate the importance of the suggested unit, he quoted an example, assuming a case of 264 stops per mile. This would mean a stop every 20 ft. or approximately equal to a landing terminal at every second floor level in a building with 10 ft. floor heights. Then in a ten story building of such proportions this service would be equal to four stops in ten floors, corresponding to the average conditions prevailing in office buildings. Then assuming a 32 story building, with story heights averaging 13 ft. on account of several specially high floors, with the same elevator traffic, or 264 stops per mile, a service would be obtained under this condition of approximately 6:10, or six stops in ten floors. It will be interesting to note on this basis, by examining the charts presented, whether 4:10 is the mean point of current consumption, or whether any other point on the curve represents the most economical operation.

E. W. MARSHALL spoke of an incident in connection with a certain elevator under test in which the motor had proved not to be heavy enough. The elevator had been tried in the shop and the motor carried the load there, because between the hours of 12 and 1 p.m. every day it was stopped and the motor had a chance to cool off. When the elevator was put into a building and ran across these mountainous peaks which Mr. Lindquist has shown in his charts, it had no opportunity for cooling off and turned out to be unfit for the work which was expected of it.

ALPHONSE A. ADLER asked two questions, one regarding the rate of acceleration of the elevator, and the other concerning the factor of safety on the ropes. According to the author's statement, he said it was about 12, but if the rate of acceleration of the elevator is considered, the stress on the rope, which is due, first, to the ordinary weight of the car, second, to the acceleration of the load, and, third, to bending

stresses in going over the sheaves, will appreciably cut down the factor of safety. There is an additional stress, aside from the bending stress and the force required to accelerate the car, which is not very frequently taken into consideration; that is, in the ordinary type of elevator, when the brakes are put on the rotating mass will be retarded, but the entire energy in the car must be taken up in the actual stress of the rope and he asked what that stress amounts to there.

H. F. GURNEY and C. R. CALLAWAY[1] (written). It was but a very few years ago that one's choice was restricted to some form of hydraulic elevator, if the rise was high, requiring a correspondingly high car speed, but recent invention and development have made the electric machine so far superior, particularly with respect to safety, the rapidity with which the car may be handled at landings, the smaller amount of space occupied by the apparatus, and the lower cost of operating, while retaining all of the hydraulic elevator's safety, reliability and smoothness of operation, that it has entirely displaced the latter from its former position of supremacy. While it is generally admitted, however, that the hydraulic elevator has been rightfully superseded by the electric, engineers are by no means agreed as to the best type of electric machine to adopt.

The only practical means of lifting an elevator car electrically appears to be by means of wire ropes, which are either wound up on a grooved drum, or driven by a traction sheave. These may not be smaller in diameter than about 50 times the diameter of the rope used, in order to keep the bending stresses low enough so that the rope will not be rapidly destroyed by breakage of the wires. Space conditions also make it necessary to keep the diameter of the drum large enough to wind up the length of rope required for the rise without making the length or face excessive, and in the case of traction sheaves, a diameter which is too small results in a decrease of tractive effort, with loss of proper control of the car on account of the resultant slippage, which also causes prohibitive wear of the ropes. We find from a consideration of these requirements that the speed of the drum or traction sheave in revolutions per minute for the car speeds used for rises of 150 ft. and upwards will fall approximately within the following limits:

Car Speed. Ft. per min.	Speed of Drum or Traction Sheave Rev. per min.
300	29 to 35
350	34 to 40
400	39 to 46
500	49 to 58
600	59 to 70
700	68 to 81

In order to drive the drum or traction sheave at these speeds electrically, two methods may be used: *a* an abnormally slow speed motor may be connected directly to the traction sheave, this arrangement being known as a 1:1 machine; *b* a moderate speed motor may be connected to the sheave through a suitable gear reduction.

We pass over, as unworthy of consideration, the arrangement in which the traction sheave runs at twice the speed required with direct roping, by the use of multiplying sheaves on the car and counterweight, driving these ropes by a motor connected directly to the traction sheave, the combination being known as the 2:1 traction elevator. This method of roping is one which has long been used for slow speed freight work, and in this class of service it is not objectionable, but when applied to high-speed passenger service it becomes a makeshift which ought not to be tolerated. The power losses are greatly increased and the cost of current made correspondingly higher, while the cost of keeping the elevator supplied with ropes is exorbitant. The fact that it is used is, however, an admission that the higher speed motor has advantages over the abnormally slow, 1:1 type. A mechanical brake is needed on the machine to bring the car to a final stop after it has been slowed down as much as possible by the dynamic or electrical braking action of the armature, and as in the 1:1 and 2:1 machines, this must act directly on the traction sheave shaft, the same as the armature, it must be a very powerful one. The wear is severe on account of the heavy pressure with which the shoes must be applied to the pulley, and the adjustments are delicate and frequently required.

The difficulties encountered in designing a motor for an output of from 30 to 40 h.p., at a speed of 50 to 60 r.p.m., are so apparent that it is unnecessary to recite them here, and the engineer's best efforts must inevitably result in a ponderous armature, wound with a large number of turns of wire, which must be of large cross-section if the efficiency is to be anywhere within reason, and an enormous field structure to carry the heavy flux necessary to develop the torque required. It imposes an unreasonable load on the building structure, requires so much space that unless the cars are unusually large it is necessary to install machines of this type on two levels, requires very expensive supports and pent-house construction, with a traveling crane of about 5 tons capacity over them to handle the pieces when taking a machine apart, and results in the machine being out of service for days at a time in case repair is necessary. It has, moreover, the poor commutation resulting from carrying heavy currents through so many armature turns, causing a high reactance voltage, and makes it very difficult to keep the commutator in good condition. A motor of this type will have so much copper on its armature that the internal voltage drop or rise caused by its resistance will result in a wide variation of speed, between the extremes which will be met in service, one of which is lifting a heavy load, when a heavy current will be drawn from the line, and the other, lowering a heavy load, when a heavy current will be generated into the line. The reduction of the speed in the first case, and the increase in the second, will be excessive, and this poor speed regulation is very undesirable in passenger service.

In any high speed elevator, it is necessary to reduce the car speed just before stopping, to a fraction of the normal speed, in order to make it possible for the operator to stop the car accurately at the floor level, and to reach the terminal landings without danger of striking the buffers or overhead work. To accomplish this reduction in speed, there are two possible methods which may be employed: *first*, an increase in the magnetic flux through the armature, and, *second*, a reduction in the voltage across the armature terminals. The former is, of course, recognized by all as the preferable means of affecting a variation in motor speed, and is in general use under all imaginable conditions, but this method cannot be applied to the 1:1 machine to a sufficient extent.

[1] Superintendent, Gurney Elevator Co., New York.

The advocates of this type will admit that it is simply out of the question to make the speed with maximum field strength less than about 45 r.p.m., which, with a traction sheave 33 in. in diameter, will give a car speed of about 390 ft. per min. As this is entirely too high a speed from which to make landings accurately, it becomes necessary to resort to the other method to reduce the speed still further; that is, to get a lower voltage across the brushes by some means. This might possibly be done by using a multiple voltage power supply, but the application of such a system presents so many difficulties, requiring complicated controlling apparatus, with special generators to supply the low voltage, that it has not been attempted.

The accepted scheme is to use resistances, one in series and one in parallel, with the armature, with means under the operator's control for varying them as required by the load in the car and the direction in which it is moving, to reduce the speed as much as may be desired. A single resistance in series with the armature cannot be used, because the counterweight is always made heavier than the empty car by an amount equal to the average load, in order to reduce to a minimum and equalize as far as possible the work done by the motor, which thus acts as a generator and returns power to the line when the car runs up with no load or a light load, or down with a heavy load. At such times the series resistance alone would result in an increase of speed instead of a decrease. In considering the circuits with this arrangement, it must be borne in mind that with any given condition of load and direction of movement, the current flowing through the armature will be a constant, regardless of whether the full line voltage is impressed upon the armature, or only a part of it by connecting resistances in the armature circuit, provided that the field excitation remains unchanged, although it is of course reduced by increasing the field strength. This is due to the fact that a practically constant torque is required to keep the elevator system in motion at any speed, and this torque is a function of the field flux and armature ampere-turns only, the speed alone varying with a change of armature voltage. The armature current when running at the slow speeds obtained by the use of the series and shunt or by-pass resistances can therefore in no case be less than that required to run the elevator under the same condition of load and direction of movement with the full line voltage across both armature and field terminals, that is, at maximum field strength.

The great waste of power in reducing the speed by this method is self-evident, but is so important and so much more than it would appear to be from a casual examination, that a few specific cases will be pointed out, in comparison with the energy required under the same conditions by a geared machine having speed control by field variation only. It will be assumed that the normal car speed is 600 ft. per min., and that both machines have traction sheaves 36 in. in diameter, running therefore at about 64 r.p.m.; that the 1:1 machine is driven by a motor so designed that the sheave runs at 45 r.p.m. at maximum field strength, giving a car speed of 424 ft. per min.; and that the geared machine is driven by a motor so designed that the sheave runs at 18 r.p.m. at maximum field strength, giving a car speed of 170 ft. per min. The latter speed is low enough to permit stopping the car at landings with sufficient accuracy, but as 424 ft. per min. is entirely too high, armature resistances must be used with the 1:1 machine to get a further reduction of speed. In making the comparison the controller contact, brush, and armature copper resistances will be disregarded, as these, while having a slight bearing on the case, are not of sufficient importance to affect the results materially. The assumption will also be made that both machines will take the same armature current to lift a given load in the car at a given speed, provided that this speed is not less than 424 ft. per min., the full field strength speed of the first machine.

No diagram is necessary to show the circuits when no armature resistances are in use, as the brushes are connected directly across the line. Currents flowing from left to right in Fig. 41 showing the connections of the armature resistances, are marked plus (+) in the Tables, and those flowing from right to left are marked minus (—). Line currents marked plus (+) therefore represent power drawn from the line, and when marked minus (—) indicate power returned to the line, and this is also the case with the line currents given for the second machine, with which no armature resistances are used, and for the first machine when running with full line voltage across the armature. The overbalance, or excess of counterweight over the weight of the car, has been assumed to be 1000 lb. for both types, although the geared machine is usually operated with less overbalance

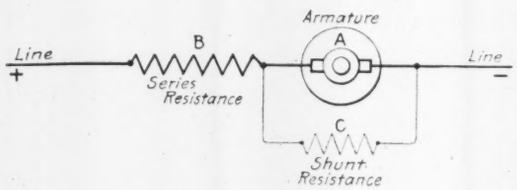


FIG. 41 DIAGRAM OF SERIES AND BY-PASS ARMATURE RESISTANCES

owing to its larger sheaves and greater traction. The net loads which must be handled by the machine, given in the second column, are therefore 1000 lb. less than the gross loads in the first column, being indicated as positive when the greater load is on the car side, and as negative when the excess is on the counterweight side. Considering movement of the car upward as positive and movement downward as negative, if the product of the signs representing load and direction is positive, the machine will be called upon to do work, as it will be lifting the weight which is greater, but if negative, the greater weight will be descending, and current will be generated in the armature.

A comparison of these figures shows that for every condition, the machine using the armature resistance, that is, the 1:1 or gearless type, takes more power as soon as these are connected in the circuit, and even though the other machine may be generating current at slow speed and returning it to the line, this gearless machine will still require a very considerable amount of power to be supplied. The moment the shunt resistance circuit is closed, whatever current the armature generates flows around it, and the reduction in total power used by the elevator that might be secured, is lost. The machine runs under this slow speed condition every time a terminal landing is approached, the automatic limit switches being set to slow down the machine at a safe distance from the floor and to cover all conditions of load, this distance is greater than an operator would require to stop the car at an intermediate floor, although in making inter-

mediate stops this condition obtains and depends upon the operator's skill in judging the correct distance from the floor to bring the car switch to the *slow* position.

In Table 1 it has been assumed that the resistances could be varied just as required to get the desired 90 volts across the brushes, but in practice this cannot be done so accurately. Approximations must be made and the speed with different loads will show a wide variation. It is necessary as well to depend upon the operator's good judgment to select the correct point on his car switch for the load in the car at the time. In comparison with this uncertainty, we have, in the geared machine, a fixed maximum field strength, giving a definite slow speed with all loads automatically, subject only to the slight variations found in a well-designed shunt motor, which are negligible.

Considering now what becomes of the kinetic energy in the moving masses when reducing the car speed by either of the methods that have been described, we find that when this is done by strengthening the field, with the armature still connected directly across the line, exactly the same result is obtained as when an unbalanced load is driving the machine; that is, current is generated in the armature and returned to the line, or if the machine is lifting a heavy load there will be a reduction in the line current, which amounts to the same thing. All of the energy that was used in accelerating the complete elevator system from the full field to the maximum speed will be returned, less the losses in the armature and gears only. As this kinetic energy varies as the square of the velocity, it will be found that the proportion of the total accelerating energy that will be thus returned by field strengthening, for the two machines we have been considering, will be 50 per cent for the first machine of the gearless or 1:1 type, with a full field car speed of 424 ft. per min., and 80 per cent for the second or geared machine, with a full field car speed of 170 ft. per min. The remaining kinetic energy cannot be usefully recovered from either machine. Although the first machine will be slowed down to 170 ft. per min. before disconnecting it from the line, thereby generating energy in the armature equal to about 30 per cent of the original total accelerating energy, it has been seen that this will all be dissipated in the resistances; none of it can be returned to the line on account of the shunt around the armature, but on the contrary, additional current will be drawn from the line through the series and shunt resistances. The energy remaining in the system when the line circuit is finally opened with the car running at 170 ft. per min. is of course lost in the dynamic braking resistance and the mechanical brake, but as this is only about 20 per cent of the original total accelerating energy, its loss is comparatively unimportant.

The armature shunt resistance also takes its toll every time the car is started, as well as when stopping, for having been left connected across the armature when the line circuit was opened, it is still there when the line is closed, and until the contactors controlling it have operated, part of the starting current flows through it, doing no useful work.

Now may be considered the possibilities of the alternate method first suggested, that is, the use of a moderate speed motor, driving the traction sheave through a suitable gear reduction. It is well known that machines of this kind, employing worm gearing, have been in general use for many years, and have proven beyond question their adaptability for service at moderate speeds. The durability and efficiency of well-designed worm gearing are quite surprising, and there is no doubt but that it would be entirely satisfactory for any car speed allowed by city regulations, if properly applied. The writers believe that worm gearing will be used for a long time to come for moderate speed machines, but when the car speed is 350 ft. per min. or more, it becomes desirable to use another kind of gearing, which recent developments in manufacturing methods have made it possible to produce economically and accurately, having a much higher efficiency and

TABLE 1 CURRENT TAKEN BY 1:1 MACHINE USING ARMATURE RESISTANCES FOR SLOW SPEEDS

Gross Load in Car	Net Load	Direction of Motion	Car Speed Ft. per Min.	Volts Across Brushes	Field Excitation	Series Resistance *B* Ohms	Shunt Resistance *C* Ohms	Amperes in Armature *A*	Amperes in Series Resistance *B*	Amperes in Shunt Resistance *C*	Line Circuit Amperes
0	−1000	Up	424	225	Maximum	..	..	−25.0	..	..	− 25.0
			170	90	"	2.0	0.97	−25.0	+ 67.5	+ 92.5	+ 67.5
0	−1000	Down	424	225	"	..	..	+52.0	..	..	+ 52.0
			170	90	"	1.0	1.08	+52.0	+135.0	+ 83.0	+135.0
1000	0	Up or Down	424	225	"	..	..	+12.0	..	..	+ 13.0
			170	90	"	1.5	0.90	+12.0	+ 90.0	+ 78.0	+ 90.0
2500	+1500	Up	424	225	"	..	..	+77.0	..	..	+ 77.0
			170	90	"	1.0	1.55	+77.0	+135.0	+ 58.0	+135.0
2500	+1500	Down	424	225	"	..	..	−41.0	..	..	− 41.0
			170	90	"	2.0	0.83	−41.0	+ 67.5	+108.5	+ 67.5

TABLE 2 CURRENT TAKEN BY GEARED MACHINE USING FIELD CONTROL FOR SLOW SPEEDS

Gross Load in Car	Net Load	Direction of Motion	Car Speed Ft. per Minute	Volts Across Brushes	Field Excitation	Amperes in Armature *A* and Line Circuit Amperes
0	−1000	Up	424	225	40 per cent	−25.0
			170	225	Maximum	−10.0
0	−1000	Down	424	225	40 per cent	+52.0
			170	225	Maximum	+21.0
1000	0	Up or Down	424	225	40 per cent	+12.0
			170	225	Maximum	+ 5.0
2500	+1500	Up	424	225	40 per cent	+77.0
			170	225	Maximum	+31.0
2500	+1500	Down	424	225	40 per cent	−41.0
			170	225	Maximum	−16.0

extreme durability, with perfect certainty of smoothness of operation, when properly designed and constructed. By this reference is had to the double helical or herringbone gear reduction.

This form of gearing is now so well known that it is unnecessary to describe it in detail, as since it was found that it could be produced so easily by the hobbing process, it has rapidly come into general use, and has been applied with entire success under the most exacting conditions of service, such as driving the propellers of steamships, where the safety of the ship is dependent upon the unfailing transmission of the power controlling its movements; or for reducing the speed of steam turbines, in which the velocity is so high that no other form of gearing can be used; or for driving rolling mills, where the severe shocks would be destructive to any other kind of gears. It owes its remarkably high efficiency and perfectly smooth operation to the continuous rolling pitch line contact of the teeth, which are so proportioned that several are always in engagement at the pitch line, at which practically all of the pressure between the teeth is transmitted without loss of power from sliding or slipping between the load-carrying surfaces. This absence of slipping also explains why gears of this type are practically free from wear.

Here it is desired to correct the impression left by the author's curves of the efficiency of herringbone gears. These apparently indicated that the gears have an efficiency of only 88 to 91 per cent—values far below those regularly obtained in good practice, which are found to be from 98 to 98.5 per cent, as determined by the writers' tests. These figures are substantiated by numerous other tests made by competent engineers, showing that when properly designed and manufactured, gear reductions of this type may confidently be expected to show an efficiency of 98 to 99 per cent. A report of tests that may be cited is one made by the Westinghouse Machine Co. on a gear reduction suitable for the propeller drive of a steamship,[1] which test showed an efficiency even higher than 98 per cent. The author said that about 1.5 h.p. was required for the agitation of the lubricating bath in which the gears run, but such a loss of power is many times the attainable minimum with thorough lubrication, which is secured by the use of a small amount of relatively light-bodied oil. As a matter of fact, the total power lost in the gear reduction complete, including the rolling tooth friction, oil agitation, and turning the main shaft in its bearings, is only about 0.5 h.p. at full load; that is, when transmitting about 35 h.p., if the gears are properly designed and manufactured.

The author also said that worm gearing was preferable to double helical gearing because it offered greater certainty of smoothness of operation. Emphatically this is not the case, and in any elevator with a machine employing well-made gears of this type, it is impossible to detect their presence, as the smooth floating motion of the car is fully equal to that of any hydraulic elevator, while on the other hand it is a well known fact that worm gearing used in elevators very often results in a trembling motion of the car, which it is difficult to remedy. In answer to the implication that gears should not be used if it is in any way possible to get along without them, a well-known manufacturer of apparatus using herringbone geared drives is quoted herewith: "While there is a general and natural objection to the introduction of gears where they can be avoided, yet here, as in all branches of engineering design, the advantages and disadvantages of one form of construction have to be balanced against those of another before a final judgment can be passed. In other words, the use of gears eliminates certain undesirable features; therefore, if gears can be made that will perform the duty, with low cost for maintenance, high efficiency and requiring little attention, is not the use of such gears the logical procedure?"

It is conceivable that if one setting out to design an automobile, allowed the obsession that gears must not be used to run away with his good judgment, he might succeed in producing a car that would run, but no right-minded engineer considers such a course for a moment. He designs a motor for the speed at which it will show the best operating characteristics, and transmits its output to the driving wheels through suitable gearing, properly designed for the functions it must perform. The prediction is hazarded that if electric cars come to take the place of the gasoline cars now generally used, the design adopted will not be one using a motor directly connected to each rear wheel. Outside of this gearless elevator, we have no examples of moderate or slow speed machinery driven by direct connected electric motors. Such a construction is used only for high speed machines, such as speed lathes, grinding and buffing wheels, and the like, which run at speeds equal to those of motors of standard design.

The author gave some figures on the accelerating energy required in starting a machine of the geared type as compared with a 1:1 machine. He gave 3060 foot-pounds as the energy required for the sheave and gear alone, and a total of 13,400 foot-pounds for the complete machine, against 2450 for the complete 1:1 machine. There is evidently some discrepancy in these figures, as it is apparent at a glance that the 1:1 armature with its traction sheave and large brake pulley will require far more accelerating energy than the much lighter gear and sheave, running at the same number of revolutions per minute. These figures really should be about 2200 foot-pounds for the gear and sheave, and about 3800 foot-pounds for the complete 1:1 machine.

While it is admitted that the geared machine will require somewhat more energy for acceleration than the 1:1, the difference is shown in correct relation to the total work of acceleration when added to the energy required to lift the unbalanced load in the car during the accelerating period of 2.5 or 3 seconds, and that required to accelerate the vertically moving masses, consisting of the car, load, counterweight, and lifting and compensating ropes, the total weight of these being, on the average, about 14,000 lb. As the maximum net load the machine will lift is usually about 2000 lb. and the distance traveled by the car while accelerating about 9 ft., the work the motor must do to overcome this resistance will be 18,000 foot-pounds, while the work of accelerating the 14,000 lb. of vertically moving parts to a speed of 600 ft. per min., or 10 ft. per second, will be about 21,800 foot-pounds. Adding to these the accelerating energy for each of the machines, including an allowance for the idler and compensating rope sheaves, we get for the total work done by the motor during the time taken to accelerate the elevator, about 44,800 foot-pounds with the 1:1 machine, and about 56,500 foot-pounds with the geared machine, these figures being roughly in the ratio of 4 to 5. The kinetic energy in

[1] Engineering News, December 30, 1909.

all the moving masses is about 26,800 foot-pounds with the 1:1 machine, and about 38,500 foot-pounds with the geared machine.

It has previously been pointed out, however, that when slowing down preparatory to stopping, a much greater proportion of this energy is returned to the line by the geared machine, which has field control only, than by the 1:1 machine, using armature resistances. It was shown that the geared machine would return to the line 80 per cent of the original total accelerating energy, less armature and gear losses, so, assuming these to be about 6 per cent, we will get credit at the wattmeter, or at some other machine, electrically, of course, for about 29,000 foot-pounds. The balance, or net charge for acceleration, is therefore 38,500 minus 29,000, or about 9,500 foot-pounds. But the 1:1 elevator will return only 50 per cent of its energy, so allowing for the same loss as above, about 12,600 foot-pounds will be returned, and the net charge against this machine for the start is therefore 26,800 minus 12,600, or about 14,200 foot-pounds,—just about one-half more than was charged to the geared machine, which has again shown its superiority. It should be remembered, however, that this does not take account of the loss of power in the 1:1 machine in the current drawn from the line while the armature resistances are in the circuit.

A careful consideration of the advantages that are secured by the use of a moderate speed motor which may be designed for any desired speed variation entirely by means of field weakening, without exceeding reasonable limitations as to weight and space occupied, in combination with a double helical gear reduction driving a traction sheave which may be as large in diameter as desired, as against the direct connected, or 1:1 machine, with the many disadvantages that have been pointed out, will, it is felt, convince any fair-minded engineer that the former is the logical construction to adopt. The results which have been obtained in actual service with the herringbone geared type traction elevator, embodying these principles, have proven beyond a doubt the correctness of this conclusion, as the ease of control, high efficiency from line to load, and small energy consumption per car mile have not only equaled, but exceeded all expectations. A line-to-load efficiency within 0.2 or 0.3 of 77 per cent has been obtained with machines which had been running only a short time, and as the efficiency invariably rises after the elevator has been in service for a few months, it is practically certain that an efficiency of 80 per cent will be reached. High speed machines of this type in office building service are operating regularly on the remarkable low power consumption of from 1.8 to 2.4 kilowatt hours per car mile, with acceleration and retardation as rapid as may be desired, and giving perfect satisfaction to owners and tenants.

In conclusion, some of the advantages of the double helical geared machine, as compared with the 1:1 machine, may be summarized as follows:

a Less space occupied in the building.
b Less expensive supports and pent-house construction.
c No traveling crane needed.
d More efficient motor design possible.
e Commutation better.
f Mechanical brake less troublesome.
g Control of car speed secured entirely by field-weakening, against wasteful armature resistances.
h Car runs at a definite speed when running slow, insuring more accurate stops.
i Higher line to load efficiencies.
j Less energy required per start and stop.
k Lower cost of operating on account of smaller energy consumption per car mile.
l Less rope wear.

In regard to the objections that have been raised to the use of gears of the type selected for these machines, attention is called to their general and constantly increasing use under the most severe and exacting conditions of service, with entire satisfaction; their remarkably high efficiency, with losses so small that they are offset, many times over, by economies they permit in other parts of the apparatus; their extreme durability, running for long periods under heavy loads and showing practically no signs of wear; their perfect smoothness of operation, which makes it impossible to detect in the car that gears have been used in the machine; their freedom from noise and vibration; and the fact that they require no attention other than an occasional small supply of lubricant. The objection to the use of gears of such qualities are so slight as compared with the many substantial advantages that their adoption for the purpose is considered fully justified, and it is felt that as the characteristics of the machine they make possible become more generally appreciated, they must inevitably be accepted as the logical and best type for high-speed service.

THE AUTHOR. In reply to the question with reference to the rope strain, I might say that by the remark that under ordinary conditions the safety factor was never less than 12, I meant the apparent safety factor with the load at rest. I did not in that statement take into account the additional stress due to acceleration and bending of the rope. That will, of course, materially reduce the apparent safety factor. If the acceleration curves shown for one particular elevator are analyzed, the additional stress due to acceleration can be determined. The stress due to bending over the rotating sheave has been approximately determined and it is not as high as is usually thought. The reason for this is that each wire is not subjected to the same strain by bending it over a sheave, as if it were a single straight wire bent over the sheave. The wire is wound up in a double spiral; the first spiral is the original spiral in the strand, and the second spiral is part of the strand itself, making really a coiled spring wound up into another coiled spring, which, of course, materially reduces the stresses due to bending.

During the last two years I have steadily tested ropes of different construction to determine the actual stresses and to determine the wearing qualities, etc. It is a subject that is altogether too deep to touch on in a few minutes, because one cannot do it justice. I may say, however, that the testing of the ropes referred to brought about some most surprising conclusions. Due to these tests I think it may be predicted that in the near future ropes employed in connection with elevators will be of different construction from those which have been used up to the present time.

Going back to the question of safety factor, if the apparent safety factor is 12, I may say the real safety factor is hardly over 8.

The rate of acceleration can be determined from the curves illustrated. I do not remember what the rate was in any par-

ticular instance, nor can I say offhand what the rate of acceleration is in any particular building, because it varies considerably. It varies with the weight of the car, the rise, the quantity of rope, and also with the service. I may say that in the Hudson Terminal Building, for example, was observed the most rapid acceleration of any electric elevators in New York City. I have determined the rate of acceleration of these elevators, and if of any particular interest it may be published at a later date.

In reference to the employment of alternating-current in electric elevator service, up to the present time no alternating-current elevators of the direct connected or gearless traction type have been put upon the market. Those that have been put on the market have been of the geared type, for speeds up to 350 ft. per min. approximately. For 250 to 350 ft. speed, two speed alternating-current motors are employed, with a speed variation of from 1 to 3 down to 1 to 4. The slowing down or the changing in speed from the full speed down to one-third or one-quarter speed is obtained by rearranging the connections of the motor in such a way as to change from a small number of poles giving the high speed to a large number of poles giving the slow speed. During this change of speed, power is actually generated back into the line, in a similar manner as in the case of a direct-current machine, when the motor field is strengthened for the purpose of speed reduction.

There was at first considerable difficulty in eliminating an objectionable shock due to reducing the motor speed to one-quarter in one step, but by proper design of motor and controlling apparatus, this was successfully accomplished.

With reference to the smooth application of the brake, no known method, at least no method known to me, has been used for magnetically retarding an alternating current brake. There we have to resort to dashpot retardation. In the majority of cases, the brake magnet parts are enclosed in oil tight casings and the brake magnetic cores are utilized as plungers to obtain dashpot action. So far as I know, this is about the only way at the present time by which a comparatively smooth application of the brake can be accomplished in connection with alternating current machines.

I may say that last year I built a gearless alternating current traction machine, but it was not designed on exactly the same lines as the direct-current gearless traction machine. It consisted of one continually revolving motor and one starting when the elevator was started and running when the elevator ran. Half of the outfit consisted of an alternating current motor, which at the time that it acted as a motor acted also as a converter. The other half of the machine consisted practically of a direct current motor having a revolving field with unusually great field variation and speed regulation. The machine was built and tested, and, so far as the speed control was concerned, it was perfect. Field regulation, from no speed up to full speed could be had; in other words, any desired speed could be obtained without resorting to control of resistance in the armature circuit. On the other hand, the losses were comparatively high and the efficiency was not very good. As far as smoothness of operation was concerned, the machine was entirely successful, but the cost of operation was comparatively high. As a matter of fact, considering first cost and power consumption together, I do not consider the machine a commercial proposition; as good results and perhaps better could be obtained by changing the alternating current by means of converters or motor generator sets into direct current and then operating direct-current elevators. The reason why this line of experimentation was temporarily abandoned was simply because it appeared very doubtful whether this type of machine could be of use commercially, even though, from a technical point of view, it proved a complete success.

The discussion by Messrs. Gurney and Callaway lends itself to comment. Presumably, in their remarks, they did not mean to imply that the use of driving sheaves a few inches less in diameter than those assumed would result in a decrease of tractive effort, slippage and undue wear of ropes. Under normal condition, the unbalanced load which can be lifted by a traction sheave without slippage of ropes depends on the arc of contact in degrees. It is independent of the diameter of the sheave, except to a slight extent; that is, increasing the diameter of the sheave may reduce the pressure per unit length of rope in contact to the extent of allowing the film of lubricant to reduce the effective traction.

Having omitted mention of the number of starts per car mile made by the elevator, their reference to a consumption of 1.8 to 2.4 kw.-hr. per car mile is somewhat lacking in significance. This will be apparent upon referring to curves in Figs. 28 and 29.

The gearless 1:1 traction machine is intended primarily for high speed, high rise service. For this service, on account of its uncommonly high efficiency (especially with average or less than half load), low power consumption and satisfactory operation, it far excels all other types of elevator machines yet developed. It is not intended to supplant the geared type of machine in its particular field of comparatively low speed and rise. In other words, the interests of clients are best served by having both types available for choice, depending upon a careful consideration of particular requirements. Manifestly, there is a field intervening that of the gearless 1:1 traction and the regular worm geared type of elevator which may be covered by either of them. When, therefore, the load required is heavy, the speed desired is between 250 to 450 ft. per min., and the service is severe—making a reduction in power consumption an important consideration, justifying a reasonable increase in first cost of plant—the use of a gearless 2:1 traction machine is most appropriate. This 2:1 type of machine combines the advantages of high efficiency (with average as well as full loads), comparatively low kinetic energy and consequent low power consumption with requirements for lower speed and corresponding heavier loads.

The efficiency of a complete installation of a gearless 2:1 traction machine is only slightly less than that of a 1:1 equipment. The decrease is due to the bearings of the sheaves mounted on the car and counterweight. These bearings are of the ball bearing type, and the friction and oil losses thereof are evidently less than those due to worm or herringbone gears. The machine of the 2:1 outfit is practically the same as that of the 1:1. The 2:1 roping is used to obtain car speeds of 250 to 450 ft. per min., instead of speeds of 500 to 700 ft. per min., usual with the 1:1 outfits. The rope speed also is practically the same in both. Both, therefore, employ low speed motors; and it should readily be apparent that the use of a 2:1 arrangement is not "an admission that the higher speed motor has advantages over the abnormally slow."

Exception has been taken to items in the tabulated comparison of the kinetic energies of a herringbone geared and

a gearless machine, presented in the paper. These tabulations were intended to be indicative of two particular machines suitable for the same load and speed. The herringbone gear was large in diameter and of substantial construction. Its weight resulted in the high energy of 2060 ft.-lb. This result, as well as all the other kinetic energies given, was derived from careful tests made in the manner described. They represent actual facts and not mere assumptions. Since it appears of interest, a similar tabulation of the complete installation, also, is here presented:

	Kinetic Energy in Foot-pounds (600 ft. Car Speed)	
	Herringbone-geared Machine	Gearless Machine
Motor armature	7420	2450
Brake pulley	2920	
Driving sheave	1000	
Herringbone gear	2060	
Secondary and compensating sheaves	1865	1865
Car and counterweight on balanced load condition	15,500	15,500
Ropes	880	880
Total	31,645	20,695

The ratio between these totals is as 6.13 is to 4 and not 5:4, as indicated in the discussion. As the use of the herringbone-geared or the gearless machine does not entail material differences in the design or layout of car, counterweight or other hatchway units, a comparison of the differences in the machines only was deemed most representative of their relative merits for elevator service and possible effect on power consumption.

Since the kinetic energy of a low speed motor is less than that of a high speed motor, the former may be brought to rest by the dynamic and mechanical brakes, with relatively less electric and friction losses and relatively less wear on the brake shoes, than may the high speed motor, even though the brake itself be, as a matter of fact, larger and more powerful.

That "the difficulties encountered in designing a motor for an output of from 30 to 40 horsepower, at a speed of 50 to 60 rev. per min.," may be successfully overcome is perhaps fully illustrated by Figs. 6 to 9 and the curves in Figs. 10 and 11. Fig. 11 relates to a motor rated at 75 h.p. running at 89 r.p.m., which had an efficiency of over 90 per cent at anywhere from merely 30 per cent of its capacity to considerable overload. The variation in car speed when ascending and descending with full load is within 5 per cent of the average speed.

In the discussion, there appears to be advocated reduction in motor speeds of 3½:1 (64:18) by means of field regulation only. From our experience with high speed shunt field motors, we should judge that so great a reduction by means of field regulation only would prove somewhat unsatisfactory, particularly for normal running conditions. With the low speed motors we use, we have, however, successfully accomplished a speed reduction for stopping of fully 2:1 by means of field regulation only.

It should be noted that a small amount of speed reduction by field regulation is more effective in stopping a low speed motor than is a greater proportionate speed reduction by field regulation with a high speed motor. This is due to the fact that facility, or difficulty, in making accurate stops depends on the amount of energy stored in the moving parts, rather than merely on their speed.

Their argument tends to convey the idea that the energy required for accelerating the elevator masses during the period of starting is available for recovery during the period of stopping, and that the gearless machine, having less speed reduction by means of field regulation, dissipates in armature resistance more of the energy available for recovery than does the geared machine, and therefore consumes in effect more power. Their conclusions appear to have been influenced also by the erroneous assumption that series and by-pass armature resistances are employed during starting.

For investigating the accuracy of their conclusions, an example may be given. For instance, let us consider the kinetic energies of the two installations to be as already tabulated, namely: 13,400 ft.-lb. for the herringbone geared machines, 2450 ft.-lb. for the gearless machine and 18,245 ft.-lb. for the hatchway units. Let us assume the motor and contactor efficiency of each installation to be 85 per cent, the gear and hatchway efficiency of the geared machine 75 per cent and the hatchway efficiency of the gearless 85 per cent. Moreover, let us assume a speed reduction by field regulation only of 3½:1 for the geared machine and 2:1 for the gearless.

Manifestly, the energy required by the motor for accelerating the elevator masses of the geared machine may be expressed as follows:

$$\frac{13400 + \frac{18245}{0.75}}{0.85} = 44{,}300 \text{ ft.-lb.} \qquad (1)$$

and that of the gearless:

$$\frac{2450 + \frac{18245}{0.85}}{0.85} = 28{,}200 \text{ ft.-lb.} \qquad (2)$$

Evidently also, the energy available for recovery during the period of speed reduction before stopping may, for the geared machine, be expressed as

$$0.85\ (13400 + 0.75 \times 18245)\ (1 - 1 \div 3.5^2) = 21{,}100 \text{ ft.-lb.} \qquad (3)$$

and, for the geared machine:

$$0.85\ (2450 + 0.85 \times 18245)\ (1 - 1 \div 2^2) = 11{,}450 \text{ ft.-lb.} \qquad (4)$$

Finally then, the difference between equations (1) and (3) and between (2) and (4) will indicate the net amount of power consumed by each elevator during starting and stopping. That is, the net amount consumed by the geared machine may be represented by 44,300 — 21,100 = 23,200 ft.-lb., and that consumed by the gearless, by 28,200 — 11,450 = 16,750 ft.-lb. The latter is only about 72 per cent of the former. This example indicates that even with less field regulation, the gearless machine consumes considerably less power for starting and stopping; and it is obvious that its efficiency is superior during running.

In response to Mr. Erlich's request the story heights of the Adams Express Company's building averaged 13.2 feet.

APPLICATION OF ENGINEERING METHODS TO THE PROBLEMS OF THE EXECUTIVE, DIRECTOR AND TRUSTEE

BY DR. HOLLIS GODFREY, PHILADELPHIA, PA.

Member of the Society.

THE problem considered in this paper is the expression of an endeavor to determine the methods by which the service of a consulting engineer may be made of greatest value to the executive of a corporation, or to a board of directors or trustees, during an interregnum in the executive office. In taking a more or less comprehensive view of problems which have confronted certain executives, and mapping out plans coöperatively with them which they could present to their directors, to their subordinates, and to their constituents, I have been forced to a regular method of procedure made practicable through coöperation of the executive and the consulting engineer. This method, which, after an experience of several years, has proven its value in money and in service, is briefly as follows:

a The defining, on the basis of facts shown by engineering study, of the policies of a business.

b The expression in simple, usable form of the definitions obtained.

c Construction on the basis of the studies made.

THE NEED FOR DEFINITION

The need for an executive to have definitions before he can make decisions is often forgotten. No executive is doing the most he can do for his business until he has obtained his definitions, by having his business fully surveyed and his fields of action selectively mapped, until he has located to the best of the present state of engineering and of industry the places where waste exists and where the greatest possibility for profitable development lies.

Such broad study, to be fully effective, must come from the coöperative use of the best methods known to engineering and to industry, through such coöperation between the industrial executive and the consulting engineer as shall combine the best of the inside industrial view of the business in question and the best of the outside view of applied science. Such a study must include or be followed by the vital but often neglected comparative and selective studies, which show what pays and what does not. To define what is to be kept and what dropped is essential to a successful business. Too often the rule is to keep everything; such a policy may have been possible in the old days of big profits, but it is no longer possible today.

THE NEED FOR EXPRESSION

To express a definition is almost, or quite, as necessary as to define, for an executive has especial reason to make his meaning clear. First and foremost, his policies must be so clear in his own mind that he can properly place them before the board of directors or trustees, if these bodies are to legislate wisely and well upon the policies placed before them. Again and again problems involving very considerable sums of money come before boards of trustees and directors, where the time of discussion of the question is limited to from one to three hours. The executive is the person to bring these problems before the board; and in order to choose wisely between different policies, in order to enable the directors to see what should be done, and to lay down a policy for the institution, the facts used must be so well chosen and selected that there can be no question of their value, and so clearly and so completely presented that their meaning can be given to a board in the shortest possible space of time.

Expression to the board of directors is but one of the problems. An executive has another duty which is often forgotten,—whether he will or no, his immediate task must be largely that of training his subordinates, of educating the men who are to work with him in the different policies of the business so that the whole staff shall work in harmony and each one understand what is behind the different policies which affect the sales, operating, and accounting departments. If the executive has not defined and expressed his policies in so simple a fashion that all his force is working in harmony, the lost motion ensuing means a loss in money which is amazing to contemplate. In many corporations, the executive has another duty, because in this day of the interest of the public and of the Government in corporation affairs, it is again and again essential not only that proper facts should be chosen, but also that those proper facts, once chosen, should be properly translated and expressed in a form which will reach a given audience, especially the broad audience of the public. Too often today such selection and expression of facts is wanting, and instead a theory or a case is presented, which may be met and conquered by another theory or another case.

COÖPERATIVE CONSTRUCTION

Money saving and money making—time saving and improvement of service—all these are intimately concerned with proper definition and expression of the facts about a business. When such definition and expression has been made, strong constructive work can be done and all three factors, definition, expression, construction can best be upbuilt through the application to industrial needs of the best that modern science and scientific methods has produced.

It cannot be too strongly emphasized that such applications of science to industry as are here outlined can best be accomplished through the coöperative efforts of engineers trained for years in science, in various types of industry and in the application of science to industry and of corporations willing to devote to such coöperative endeavor the cordial assistance of employees trained for years in the details of their own business. Neither from without nor within can the best results be secured. Advances can best be made through the welding together of the two types of knowledge possessed by two groups of men, one possessing general knowledge of science and industry and one possessing specific knowledge of a given business.

Presented at the New York local section of the AMERICAN SOCIETY OF MECHANICAL ENGINEERS on March 9, 1915.

METHODS OF PROCEDURE

There are six divisions, as I have seen them develop, which very much concern a consulting engineer who is serving any corporation along these lines. The final thing is, of course, the decision, and it is the executive or the board who knows five or ten per cent more than the other man who decides promptly, and in most cases decides rightly. It is, then, a function of the consulting engineer to present such facts to the executive that the basis of the decision made may be as sound as possible; he should place before the executive:

a A general preliminary coöperative study of the field to determine what lines are most worthy of study.

b A coöperative determination of what facts should be known about the lines selected and a definition of the periods most worthy of study on the basis of the preliminary study.

c A careful collection and intensive study of the facts existing in the lines chosen for the periods determined.

d The translation of the facts collected and studied in the light of their relation to the other departments of the business.

e The expression of the facts studied and the results obtained, in the briefest and clearest way.

f A method for the constructive use of the facts obtained and where necessary, an expression of the facts in a form intelligible to the special audience which needs most to know them.

THE TASKS OF EXECUTIVE AND ENGINEER

Turning to the first heading, the need for a broad, comprehensive view of the whole problem, it seems to me that every executive must realize the fact that it is his task to determine the internal policy and the external policy of his company, and that those policies, which make up the policy of the business, must rest primarily upon the history of that business and upon the facts of the business and its relation to its world. He should also realize that he can best obtain the necessary data as to both history and facts through the coöperative assistance of the engineer. No consulting engineer can possibly know as much of a given business as can men who have been trained for years in that business: but it is equally true, though sometimes forgotten, that no business executive can know as much of scientific methods as applied to industry as the engineer—each has his own knowledge, his own training, his own experience. One has the inside viewpoint; the other, the outside viewpoint. Neither can do a complete job alone. The peculiar value to industry of the engineer who possesses training and experience comes largely from the fact that such an engineer can choose the most vital physical facts and bring them into such relation that they may be clearly and briefly expressed, and because the engineer's knowledge makes possible the discarding of useless statistics. The need for training and experience in the determining of what facts to collect and what lines to study can hardly be made too emphatic.

The problem, then, for the engineer is to use his viewpoint, to use the scientific method undimmed by too much technique of the business, coöperatively with the executive in the collection and translation of the facts, to bring the essential factors from the cloud of nonessentials, and to define and express the clear-cut, sharp, comprehensive policies which should be pursued.

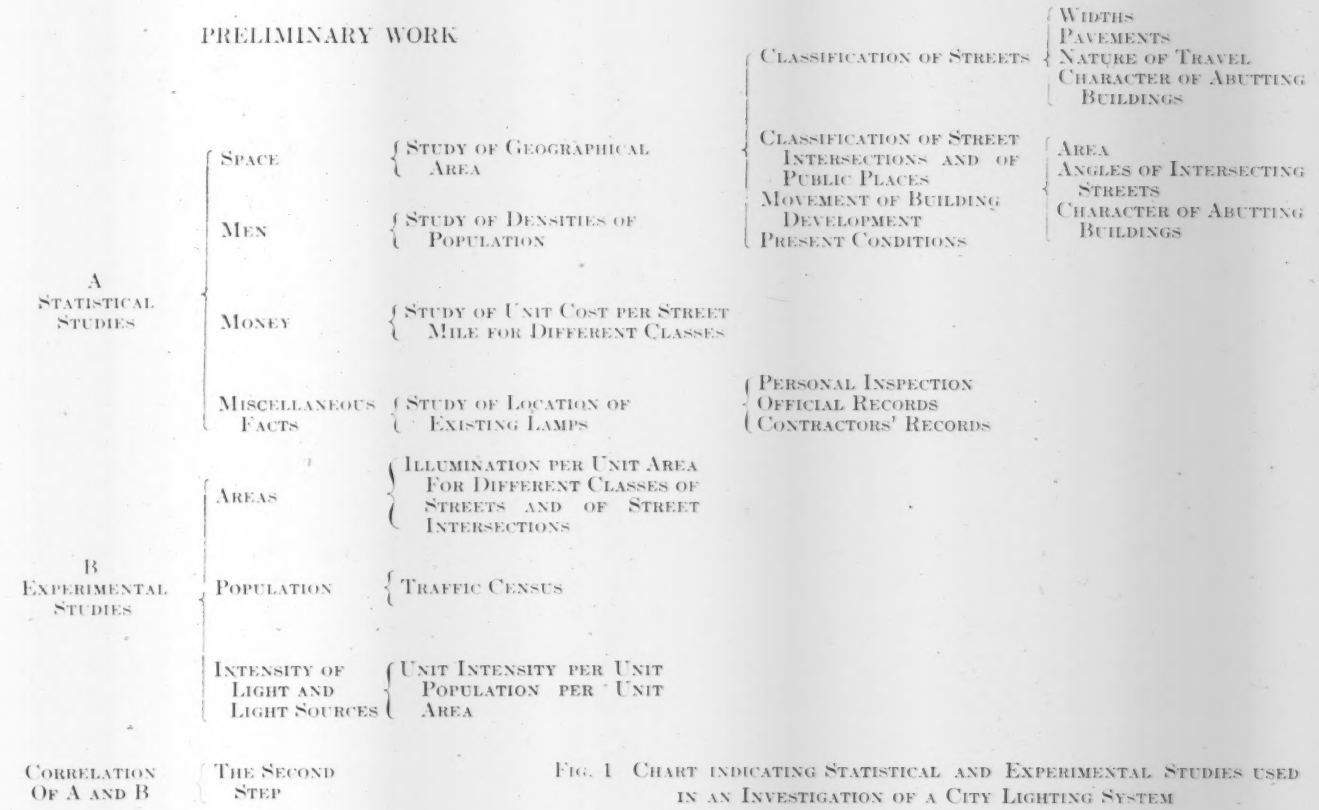


FIG. 1 CHART INDICATING STATISTICAL AND EXPERIMENTAL STUDIES USED IN AN INVESTIGATION OF A CITY LIGHTING SYSTEM

The problem for the executive is to aid the engineer by giving him the facts about the business, and by assisting him in determining the practicability of his suggestions. It must be remembered also that both executive and engineer must be open minded, if coöperation is to succeed. It is comparatively seldom that an engineer is asked to lay out a wholly new plant. He is generally doing the best he can with an old one.

One may often see in the records of many corporations the rings of age showing as many periods of growth as the rings around a giant sequoia. To determine the meaning and value of these different rings, to understand their translation, to find out what is orderly growth and what is disease excrescence, to determine what should be fostered, to devise means of loosening cramping bands which have grown up

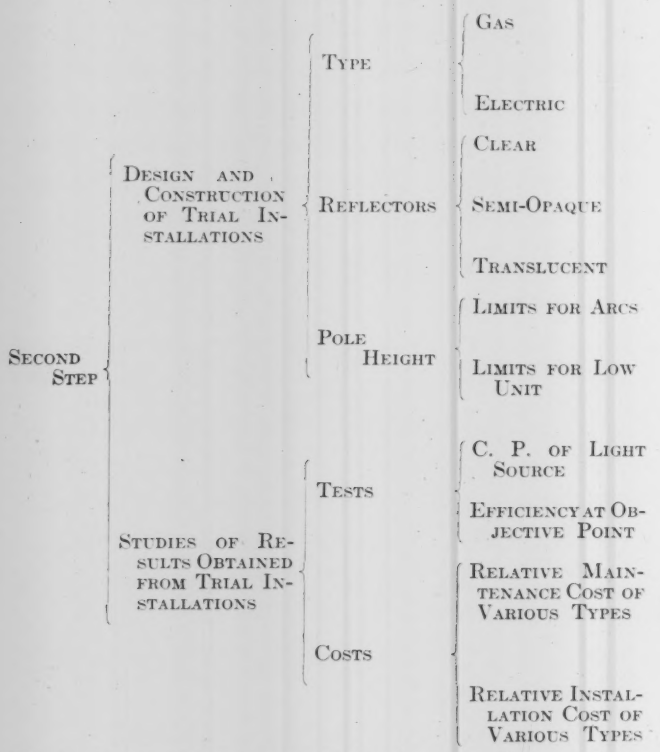


FIG. 2 STUDIES OF LIGHTING EQUIPMENT AND RESULTS FROM TRIAL INSTALLATIONS

around the business,—that task should be done best by the methods outlined here.

There is another reason why the obtaining of a broad comprehensive view is essentially a function of the outside engineer, even where the executive is himself an engineer. I personally believe that no man can get along without an outside view upon his problems, and that the executive is always dimmed by his nearness to the problem. I question whether any sincere man will deny that he has certain preferences for the work he is doing himself, or question that no matter how completely he endeavors to gain an unprejudiced view of his daily routine he is somewhat affected by a glamor of personality.

As I indicated before, the internal view is but one of the factors in the situation. No business lives alone. Not only within the business, but outside the business, any individual institution or corporation whose aims are clearly defined and rightly defended and expressed can remove to a large degree any unpleasant relations with other corporations, with legislatures, with public service commissions, and with the public generally. Such questions as the following are constantly arising: What is the competitor's policy as compared with ours? What is being done in his field, and how does his field relate to ours? What will a legislature or a public service commission do that affects our future? What will the public reaction be upon a given policy? All uncertainty as regards the answers to these questions is largely cleared away when any branch of industry has a clearly set forth and definite policy, clearly expressed, and based upon proper study of the facts not only of its interior but of its exterior relations.

A BROAD COMPREHENSIVE STUDY

An illustration of a rather broad and comprehensive study made for an executive and a board, the results of a year's study of a problem, which included a survey of the whole field and a selection of those lines which seemed most profitable for investigation, is stated as follows:

Given a city with one hundred miles of streets and public places to be lighted and with a maximum population of a quarter of a million, provide the best light at the lowest cost.

In this investigation we first made a preliminary study, and laid out a work chart, Fig. 1, showing certain statistical and experimental studies that we desired to follow out. Under *space* we studied the geographical areas, and made a classification of the streets,—widths, pavements, nature of travel, and character of abutting buildings, taken from the highway plans of various streets, and arranged in groups. We then classified the street intersections and public places, found the areas, angles of intersecting streets, character of abutting buildings, particularly with regard to automobile travel and possibilities of bad lighting at the intersections. We determined the present condition in the case of the streets and intersections and public places.

We then studied the densities of population, and also studied with relation to these densities of population, the movement of building in the last five years and how the building had progressed in different periods and under different conditions in the city. As a matter of fact, the popular estimates of what building had occurred, were largely incorrect until we made this study, and the people of the city thought the facts about the city were quite different from what they actually were. We found that while the movement of building was supposed to be greatest in one direction, it was actually greater in another direction.

We then went on with the question of money, and studied the unit cost per street mile for the different classes of lighting for the different streets.

In regard to miscellaneous facts, we studied the location of existing lamps, from personal inspection, from official records, and from the contractors' records and comparing the city records with the contractors' records. The lighting had gone on as most lighting goes, in a varying manner; one year the appropriation had been large and there had been a lot of lamps put in as a result of new developments started. The next year the development died out, for some reason, and a lot of lamps had not been placed, and some of those which had been put in place were not effectively used. The result was that there was no regular distribution of lighting.

The heading "experimental studies" represents definite

experimental work. We put up adjustable standards similar to those used by the Edison Company, the Electrical Testing Laboratories, and by Mr. Lacombe in the New York City tests, and also similar to various other experimental plants elsewhere. Under "areas," we studied the illumination per unit area for different classes of streets and of street intersections. We studied the population and traffic census, especially with reference to foot traffic and automobiles, and incidentally let me say that in a similar study to this we found one interesting thing where we made a very considerable mistake, one which would have made much trouble if we had not been working coöperatively with the officers of the city, and had not invited them to criticize freely our studies. We took the traffic census on a given road and found there were only eighteen vehicles going up that road. We checked it up, and one of the persons familiar with the situation said, "There is a big mistake there, because that is where the early morning trucking goes." We went back and made the study between two and six o'clock in the morning and found over a hundred trucks coming in over that road, which went out late in the afternoon. In the late

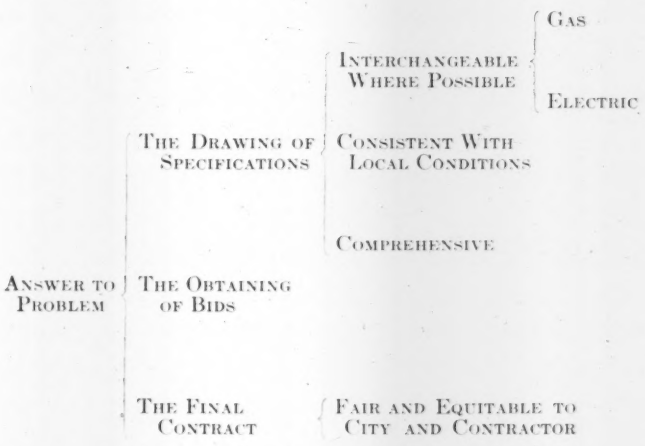


FIG. 3 CHART INDICATING ANSWER TO THE PROBLEM

morning, when the study was taken, there was almost no traffic on that street. There is an illustration of the necessity of coöperating with the people in the place, to find out what the facts are about the actual conditions. If we had not checked that study street by street with the people who knew the conditions, we should have based our lighting for that road on the morning study, and found no traffic worthy of mention.

Under "intensity of light and light sources," we determined the unit intensity per unit population per unit area, and in getting that together there is only one conception, practically, that one should give the executive to use, and that is the conception of the unit, the concept of the candle, because after all our light unit comes back (with full recognition of the carefully drawn and admirable work of the Bureau of Standards), to a concept of a candle, just as density of population or unit population goes back to the conception of one man in one house, and that unit concept can always be given simply and directly. Almost the only thing used in the preliminary work, which needed any translation, was the word "unit," (and we only used that because we had to use the unit concept) and we found that was easily translated, even with the men on the street.

We then took up the question of design and construction of trial installations for both gas and electric lamps, Fig. 2. In the case of reflectors, we studied the clear, semi-opaque, and translucent. We also studied the matter of pole heights, limits for ares, and limits for low units. We made studies of results obtained from trial installations, and made tests to discover the candlepower of light sources and their efficiency at given points.

In considering the cost of this installation, we then proceeded to a study of the relative maintenance and costs of various types.

The answer to the problem was the final drawing up of specifications, Fig. 3, making the gas and electric units in-

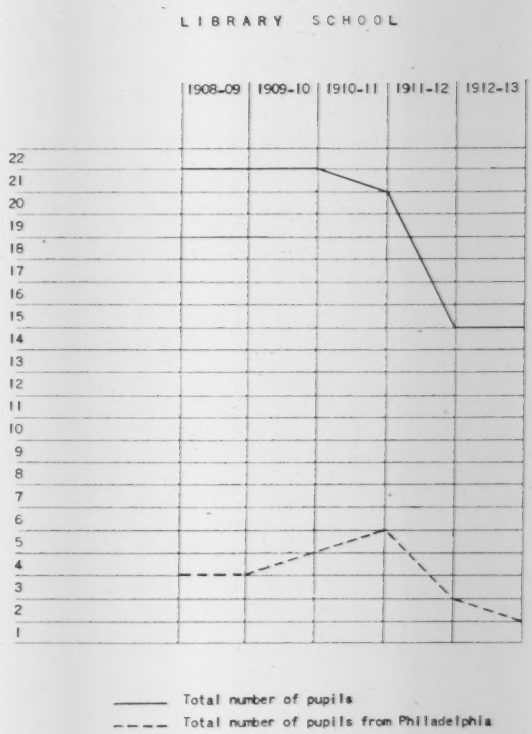


FIG. 4 STUDENT ENROLLMENT FOR FIVE YEARS

terchangeable where possible, and making specifications consistent with the local conditions which did not require tests of an expensive nature to be carried on, and which would be comprehensive. It is impossible in any chart to show all of the different factors which concern specifications in general. Perhaps there is no more dangerous fallacy than the concept that a specification which can be used with great satisfaction in one plan can be used with equal satisfaction in another. The main thing which we desired to obtain was a final contract which should be fair and equitable to both the city and the contractor.

Such a study as I have shown here is a brief representation of my first concept which concerned the possibilities of engineering work done coöperatively with an executive in obtaining broad, comprehensive views for the education of associates, for the public, and for the authorities.

A SELECTIVE STUDY

The second division of my subject concerns the application of the theory of selection to the different parts of a

problem in such a way as to enable any executive to understand those factors in a business which are more valuable and those which are less valuable. Certainly if there is a branch of engineering which, from the standpoint of money returns, needs most to be applied to industry, it is such studies as shall give readily to the executive and to legislative bodies and corporations that concept of the selective values of their business. There is no way I know by which this can be obtained save through engineering studies of the type illustrated here;—for there are very few businesses which are so simplified that one can tell offhand at a glance what line will pay and what line will not. Such

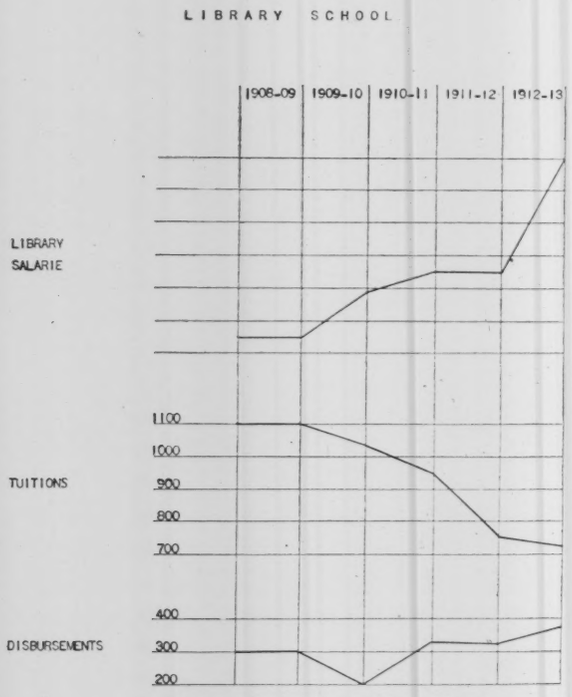


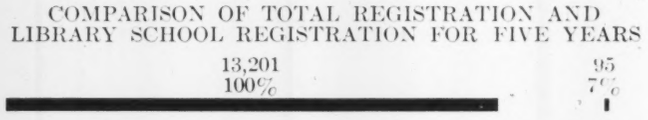
FIG. 5 COMPARISON OF SALARIES, TUITIONS AND DISBURSEMENTS FOR FIVE YEARS.

studies as those concerned with the possibilities of obtaining raw material, of development of transportation, of the labor market, and of selling fields,—all come into this group and concern such comparative information as shall make selection between different problems possible. Such comparative information as will enable the executive to know which part of the business will be mainly effective, provides the means by which the executive may select what shall be pushed and what shall be held, what shall be dropped, and what shall be left for a future time or for future stimulation. It is upon such selective decisions that again and again large decisions may hinge.

I had made a number of studies of this nature when I went to the Drexel Institute as president, and found there a number of departments which had grown in the same way that most of the departments of the small college grow. There was a period in American life when the small college endeavored to be a university without success. That period is, fortunately, passing, and we are coming to realize that there is a definite place for the small college and a definite place for the university. During that period a number of admirable schools were added to the Institute, and since one of my tasks, when I went to the Institute, was to determine which of those schools were worth while, which should be selected to remain, and which could properly be dropped, I recognized that I must make for myself such a study of selective values as I am outlining here. Among our other departments we had a Library School which in many ways had done admirable work; this was studied among others.

The first thing concerning the Library School that we studied was the curve of students for five years, from 1908 to 1913 (Fig. 4). And as regards the period to be studied, it should be noted here that nowhere else do training and experience as the part of the engineer count more. The analysis of periods which are too long or too short may easily prove not only wasteful but actually misleading. The second problem came in connection with library salaries, tuition, and the disbursements. We found that the library salaries rose considerably, and the disbursements remained about even, while the tuitions fell off materially (Fig. 5).

The total registration of the Institute was 13,201 for five years. Our Library School registration was 95, or 0.7 per cent. The total number of graduates for thirty years' existence of the school was 317. We then studied a comparison



TOTAL NUMBER OF GRADUATES FOR TWENTY YEARS EXISTENCE OF THE SCHOOL, 317.

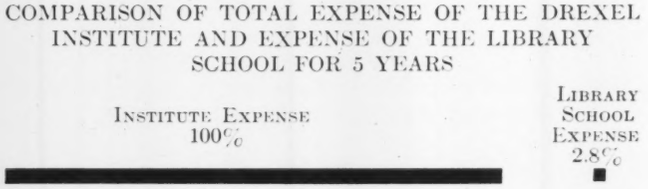

COMPARISON OF TOTAL EXPENSE OF THE DREXEL INSTITUTE AND EXPENSE OF THE LIBRARY SCHOOL FOR 5 YEARS
INSTITUTE EXPENSE
100%
LIBRARY SCHOOL EXPENSE
2.8%

FIG. 6. COMPARATIVE STATEMENTS OF REGISTRATION AND EXPENSE.

of the total expense of the Drexel Institute and expense of the Library School for five years. The total Library School expense was 2.8 per cent of the total Institute expense (Fig. 6).

We then took up the question of the employment field for the graduate of the Library School. We found in comparing the number of positions and salaries in a selected group of Philadelphia libraries, that there are one hundred and twenty holding positions in selected libraries, drawing from $216 to $600 per annum; thirty-one drawing from $600 to $720 per annum; twenty-seven drawing $900 per annum; and twelve drawing over $900. In five years all the general libraries in Philadelphia took direct from the Library School seven graduates. Total notices on file of vacancies in libraries of the United States for the past five years at salaries of $600 and over, were one hundred and sixty-six (Fig. 7). It should be remembered, of course, that this employment field is for young women graduates, but it must be equally remembered that this is the record for five years. On the basis of the facts shown above, the board decided that the Library School should be given up.

This method is applicable to any business. I have no question that by varying the means of treatment with the necessities of the case, you can determine, to a considerable degree of accuracy, what is right to keep and what is right to eliminate. The educational example used here is chosen as an illustration.

I have already spoken of the question of the time-saving factor in the preparation of reports. The average director or trustee is a busy man. The meetings of the boards of directors or trustees which I have attended in different parts of the country have almost always been brief, a condition which calls for such rapidity and such pointedness of statement, as shall bring conviction to the eye as well as to the ear, and will make possible wise legislative action upon the part of the board. If the proper ends are to be obtained, clarity as well as brevity is essential.

Since 1906, I have been largely interested in the study of engineering reports from the standpoint of clearness. The inadequacy, diffuseness, and obscurity of many of these reports is remarkable. Reports to be read by laymen are either couched in technical language difficult of comprehension, or so much material is laid before the public that they are commonly unable to come to the final, sharp, clear understanding of what is meant, and such lack of expression is a great handicap to our profession.

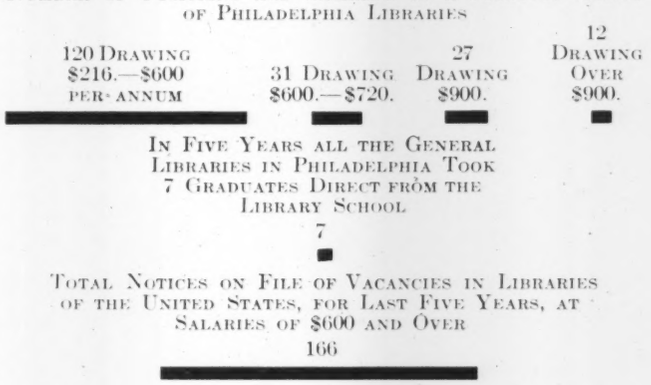

LIBRARY SCHOOL
Number of Positions and Salaries in a Selected Group of Philadelphia Libraries
120 Drawing $216.—$600 per annum
31 Drawing $600.—$720.
27 Drawing $900.
12 Drawing Over $900.
In Five Years all the General Libraries in Philadelphia Took 7 Graduates Direct from the Library School
7
Total Notices on File of Vacancies in Libraries of the United States, for Last Five Years, at Salaries of $600 and Over
166

Fig. 7 A Study of Library Positions and Salaries

A STUDY IN CLARITY

Fig. 8 shows the summing up of the results accomplished through a study of the type outlined above and through construction on the basis of the study, and illustrates the principle of clarity which it is desired to show.

The results concern the regular delivery of thousands of papers called for daily on the requisitions of clerks. No mention is made of the emergency system of delivery which was constructed in order to care for all such requisitions. The problem here so far as the regular delivery from the file room is concerned resolved itself into four phases:

a Diminishing of the time required to fill requisitions. The work done reduced the time in question from five to three hours according to the records made.

b Regularity of delivery. The installation of a controlled system of transportation replaced irregularity of delivery with controlled and inspected regularity.

c Reduction of irregular messenger service carried on by department clerks. This irregular service was abolished and the whole messenger service carried on by the two boys who had previously done but a part.

d Completeness of delivery. This was provided and assured by a complete system of inspection. The entire differences in service noted here was accomplished without increase of working force but actually with a decrease.

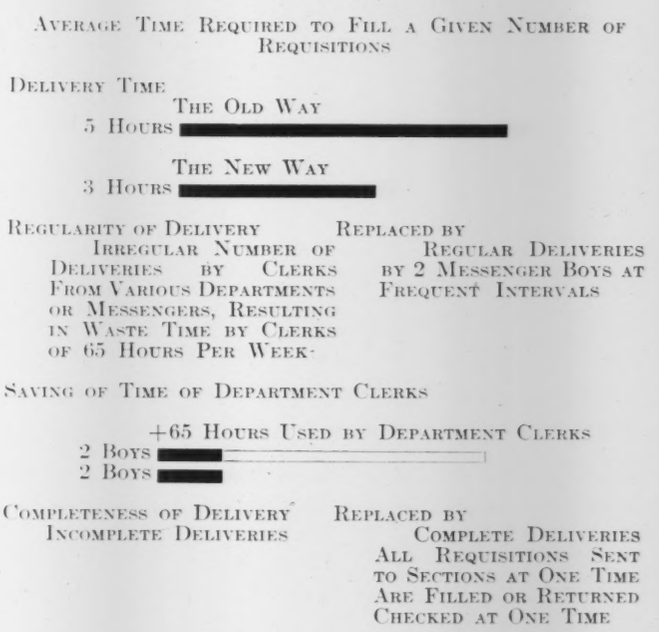

ONE OF A GROUP OF CHARTS EXPRESSING RESULTS FROM A STUDY OF A LARGE FILE ROOM
CHART A
The Result in Service
Average Time Required to Fill a Given Number of Requisitions
Delivery Time
The Old Way
5 Hours
The New Way
3 Hours
Regularity of Delivery
Irregular Number of Deliveries by Clerks From Various Departments or Messengers, Resulting in Waste Time by Clerks of 65 Hours Per Week
Replaced by
Regular Deliveries by 2 Messenger Boys at Frequent Intervals
Saving of Time of Department Clerks
+65 Hours Used by Department Clerks
2 Boys
2 Boys
Completeness of Delivery
Incomplete Deliveries
Replaced by
Complete Deliveries
All Requisitions Sent to Sections at One Time Are Filled or Returned Checked at One Time

Fig. 8 Plan followed in Summing up the Actual Results

A STUDY IN BREVITY

Brevity is also essential in an engineering report. It is necessary to attack the problem in such a way as to give definite and complete information to a limited, definite and complete group. The engineering report is a translation of physical facts to be used in many cases for the information of groups. The group of people for whom that report is written should be considered quite as much in an engineering report as in any other translation of physical facts on paper.

To come to a specific case in Fig. 9, I have constantly found that the question of prices was one of the most difficult things to go into in a short space. I have spent a considerable amount of time in endeavoring to get all price facts about several businesses on a single sheet of paper. The facts were on 34 pages of catalogue when I went to the Drexel Institute, and one would have to read over 34 pages of this catalogue to get all the facts about the different fees and and different items of cost information one would naturally desire. To solve this problem we standardized on fees, and put them all into a single place, and for the sake of clarity stated in all cases three things, the amount, what the student obtained for the amount, and when it was

payable. These are the three questions that are always asked by prospective students and their parents.

REQUIREMENTS OF AN ENGINEER WORKING IN THIS FIELD

There is no question that there is some opposition to any question of engineering study, or especially of any engineering investigation. Most of the present justified feeling against the very word *investigation* has come because of the defects of the investigator. Much of that opposition has come because it was assumed that the engineer was working to investigate or find fault with somebody, instead of working coöperatively with the men in the business to do the most that could be done for the business. Moreover, to make savings of money, service, and time, the coöperative engineering adviser to an executive must be able—

a To distinguish clearly between records which are vital to the future policies of a business and those which are merely historical. The past in industry as a determinant for policies is of value only as it is vitally concerned with the future.

b To omit many engineering refinements, that cost much money and lead to a "false and delusive accuracy," as one of my old instructors used to put it; to avoid, so far as possible, in all cases doing work that "costs more than it is worth."

c To check his work with the practical needs and limitations of the business, keeping an open and perceptive mind.

d To change his methods for the better with the advance of the engineering and industrial art—in short to keep abreast of the "best of the art."

e To have a wide acquaintance with those men of his profession and of other professions and callings, who know most of special lines of which he may need to know.

f To bring the best that science and industry has yet produced to bear upon the problem before him.

Those are serious requirements to lay down. Yet there is no small number of engineers who I know could meet them all. They can hardly be made materially less, for in work like this the danger of construction turning to destruction in untrained hands, presenting ill digested, wrongly collected, wrongly translated, and wrongly expressed facts, is too great to be readily assumed.

FEES AND STUDENT EXPENSES OF THE DREXEL INSTITUTE

TUITION	$100. Received in Instruction During Year
Paid to Registrar of the Institute	
$50. Paid on first registration day.	$50. Paid on second registration day.
INSTITUTE FEES	**STUDENT EXPENSES**
Paid to Registrar	Paid elsewhere than to the Institute.
Supplies and Laboratory Equipment.	Books and Supplies.
$20. Returned in experience with visible materials used in class during year. Paid to Registrar first registration day.	$25. Received in visible property largely left at end of year. Expenditure made by student at various times during year.
Student Activities.	Material for Apparel.
$10. Returned in better health and social experience during year. Paid to Registrar first registration day.	Amount largely dependent on student. Received in visible property. Expenditure made by student at various times during the year.
Deposit.	Incidental Expenses, Lunches, Car Fare, Etc.
$5. Returned in cash if nothing is broken or lost. Paid to Registrar first registration day and covers keys and breakage.	Amount largely dependent on student. Expenditure made by student.

FIG. 9 CHART INDICATING METHOD OF BRIEF AND COMPREHENSIVE GROUPING OF COST DATA

FACTS VERSUS THEORY.

There is another matter which affects very considerably, as I said at first, any problem in engineering investigation, and any problem of expression of engineering facts, and that is the fact that people to-day are looking, it seems to me, for facts properly expressed rather than for legal cases. Again and again in this country we have suffered from one case placed against another, one theory placed against another theory; and I believe that the period is coming more and more when the facts are going to settle problems; but facts alone are not enough. It is only when facts are expressed in such a fashion as to reach the definite audience which it is to reach that facts really gain the day.

On this whole question, it would seem to me that it is of vital importance to the profession to show the industries and institutions of this country the value of such engineering service as I have outlined here, and perhaps also the need to have engineers with training, experience, and the power of expression carry on this work. I have endeavored to express here in concrete form a method of precedure which has been followed by several of my friends, and by myself, in recent years. In my own case, I have been working consciously along this line for the past eight years, during which time I have been concerned with a number of studies of institutions, corporations, and businesses. In each of these, I have endeavored to make of the study a logical whole which should be practical, selective, simple, brief, effective, and properly expressed.

In conclusion, I believe that work of this type offers a great field for the trained and experienced consulting engineer, and that industry in the next few years will realize the need of the consulting engineer as never before. We have for a very long time had to do with the consulting lawyer. I believe the executive of the near future is to be more and more ambidextrous in his counsel, having his lawyer on one hand and his consulting engineer upon the other. We must obey the laws of man, but it is even more necessary to obey the laws of nature, and the consulting engineer is as much needed by the executive, to aid him in the determination and expression of the facts, as his counsel is to tell him what his legal rights are and in what way he can lawfully carry on his work.

FOREIGN REVIEW AND REVIEW OF THE PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

EFFECT OF THE WAR ON FOREIGN PERIODICALS

As has been before pointed out, the events in Europe have seriously affected the amount of engineering material published in the current foreign periodicals. Some of the publications have been entirely discontinued for the present; the others, and among them the leading engineering magazines, have cut down the amount of space in each issue. Then again, many appropriations for research in engineering schools and works of manufacturing companies have been cut down for various reasons, while—and this is the most unfortunate feature of the entire situation—thousands of engineers have been diverted from their regular work to military duties through which many of them have already lost their lives. A vigorous effort is being made, however, to maintain the Foreign Review section of the Engineering Survey at its usual standard.

THIS MONTH'S ARTICLES

In the present issue an article discussing the use of liquid air as an explosive, chiefly for mining and constructural purposes, is abstracted. Its most important features appear to be comparative safety, especially in the case of misfires, and the possibility of manufacturing it in any country where there is a source of power. In the same section is described a new type of two-stage single cylinder compressor of apparently simple and rugged construction.

The "Uto" two-stroke cycle engine, built by a Swiss concern, seems to be also of a very simple design. In addition to that, it has an interesting system of water cooling without water injection into the interior of the cylinder. It has also an interesting and novel form of packing about the main bearings. Some data of tests of the engine operated with crude oil are reported.

The question as to whether ammonia explosions do actually occur in refrigerating plants is carefully considered in a report of an article by G. Cattaneo.

A system of oil separation from water of condensation with particular reference to large power plants and mining plants is described by Mr. Vahle.

From a German periodical is briefly abstracted an article on fireless locomotives, in which, among other things, is contained the statement that such a locomotive used 2½ years fairly continuously in the works of a machine company, cost less than $12.50 in repairs for the entire period.

The present scarcity of copper in Germany called attention to the possibilities of the use of wrought iron in locomotive fire boxes and G. Hammer shows that such a use is also favored by the present conditions of railroad operation and train handling.

The Mellen rod casting machine is described in a paper before the American Institute of Mining Engineers.

The journal of the American Society of Heating and Ventilating Engineers appeared in April in a new form. An article on the measurement of air flow, of considerable interest, is briefly abstracted from it.

From the Memoirs of the College of Engineering, Kyoto Imperial University, is taken an abstract of the main data of tests on the combined bending and torsional strength of cast iron.

Very interesting data of tests on a recent type of chain grate stoker and new methods of baffling Stirling boilers are reported from a paper before the Engineers Society of Western Pennsylvania. From this paper, it appears that a material gain in efficiency is obtained by the use of what the author called the "slow chain" method of firing.

The lateral friction of winding ropes and the magnitude of the angle of maximum friction are discussed in a paper before the Institution of Mining Engineers (London).

Several papers are abstracted from the transactions of the North-East Coast Institution of Engineers and Shipbuilders, such as tests on a Diesel engine in which were used with considerable satisfaction rotary indicator diagrams, and results of substantial interest which have been obtained. The influence of various temperatures on the properties of Admiralty gun metal are discussed by Professors A. Campion and John G. Longbottom, who reported several phenomena bearing on the structure of metals. An interesting paper on the strength of welds made by the acetylene process was presented before the same organization by Professor Campion and W. C. Gray, in which it is again shown that oxy-acetylene welds are not as strong and are less reliable than the unwelded portion of the metal. It was also shown that hammering, while increasing the fatigue resisting properties of the material, may also be productive of brittleness, and that reheating and annealing alone appear to be of little value so far as increasing the fatigue resistance in the welded portion is concerned. Further, that the thicker the plate the less reliable is the weld and the greater the reduction in strength.

From the Journal of the Western Society of Engineers are abstracted two papers, one on the electrification of steam railroads and another (really two papers on the same subject) on wind stress in the frames of office buildings. Particular attention is called to this latter.

FOREIGN REVIEW

Air Engineering

LIQUID AIR AS AN EXPLOSIVE, M. Przyborski

Data on the use of liquid air as an explosive, in particular on the Kowatsch system.

Professor Linde appears to have been the first to introduce successfully an explosive consisting of ground charcoal and liquid air. Since then, Claude and d'Arsonval, in France, have further developed these processes and finally Kowatsch and Baldus, in Germany, have lately worked it out still more fully, partly under the pressure of the present demand for an explosive of exclusively German manufacture.

In order to avoid excessively rapid evaporation of the liquid air, Kowatsch, who uses a cardboard cartridge, introduces first a cartridge with dry carbon into the drill hole separately and without any liquid air, which is put in only just previous to ignition. This process permits reduc-

ing to a minimum the period of evaporation, and also increases the factor of safety of operation.

The cardboard cartridge contains a perforated pipe in which there is a mixture of infusorial earth with oil and asphaltum or lamp black and paraffin, neither of which is explosive in itself. This center pipe contains another cardboard tube over which a third cardboard tube is set, serving as an exhaust pipe for the products of evaporation of liquid air. If several drill holes have to be exploded simultaneously, the electric connections are made accordingly.

The liquid air which has to be used for each hole is kept in a precisely determined quantity in a small bottle, the opening of which is provided with a metal tube and conical nozzle, connected with the central tube of the cartridge. To load the cartridge, all that is necessary is to lift the rear end of the bottle. The liquid air is raised by the pressure of its own products of evaporation and gradually passes into the cartridge. At the instant when the charge is ignited by the electric spark, the liquid air combines with the charge and there follows an explosion of exceptional violence.

Among the advantages of this method of explosion is the fact that, in the first instance, the materials used are not explosive in themselves and the explosive mixture is formed only at the very last moment in the bore hole itself. In the second place, should an explosion be missed, the liquid air will evaporate and the remaining cartridge is perfectly harmless. (*Verwendung von flüssiger Luft als Sprengmittel nach einem neueren Verfahren,* M. Przyborski. *Zeits. für Eis- und Kälte-Industrie,* vol. 7, no. 9, p. 93, March 1915, 2 pp. *d*).

A Two-Stage Single Cylinder Compressor

Notwithstanding the fact that there are a number of two-stage single cylinder compressors on the market of really good efficiency, new types continue to be introduced and adopted in practice. The author ascribes this to the fact that the two-stage single cylinder compressors introduced so far all suffer from excessive space demand per unit of output and insufficient accessibility.

From this point of view the new compressor (built by Maschinenbau-Aktiengesellschaft Marktredwitz, vorm. Heinr. Rockstroh in Marktredwitz, Bavaria, Germany) described in this article, strikes one as being of very compact design and substantial construction. It is designed in such a manner that it rests on a foundation throughout its length, which tends to eliminate vibration; further, the suction and compression valves on the low pressure side are located on the cover of the low-pressure cylinder which is designed as a valve chamber.

The atmospheric air, after having undergone preliminary compression in the first stage, passes through the compression valve on the low-pressure cylinder cover into an intermediary cooler. Then, through the suction valves of the high pressure stage, it reaches the annular space of the stepped piston, of which the differential area (see Fig. 1A) forms the high pressure cylinder, and here the air undergoes a second stage of compression. As soon as the desired first stage of compression is effected, the compressed air is transferred by the pressure valve to the high pressure side.

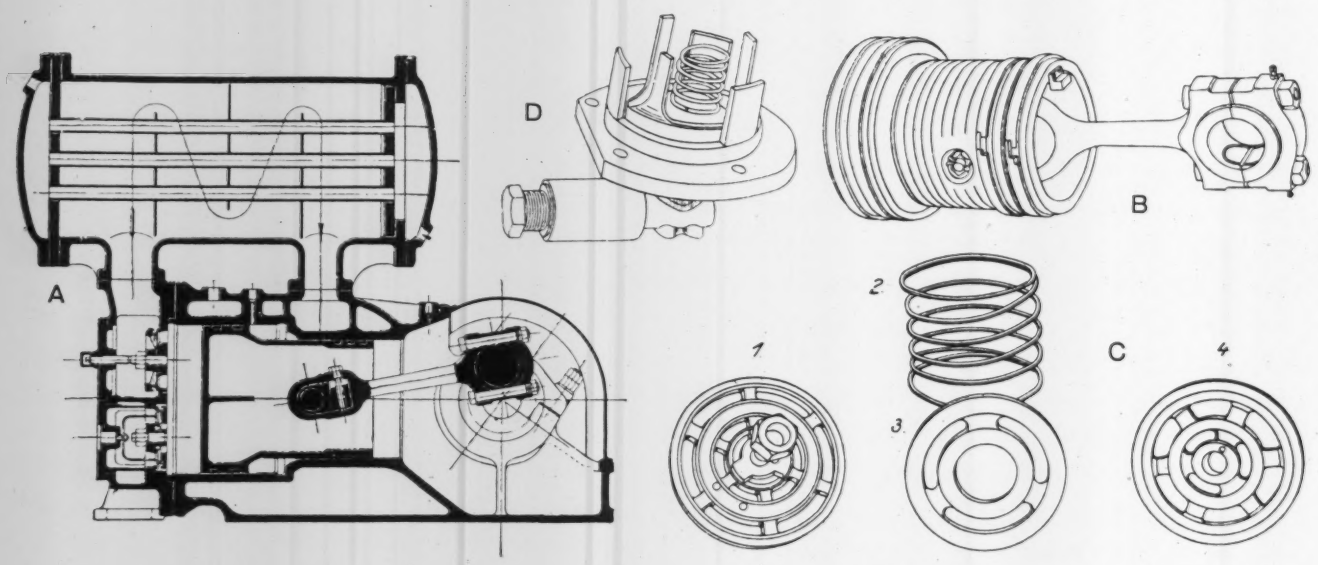


Fig. 1 Two-Stage Single Cylinder Compressor

The piston (Fig. B) is made of gray cast iron. As a two-stage piston, it carries, on both the high pressure and low pressure side, self-tightening packing rings made of alloy cast iron. The pin is set inside the piston and has an extremely hard surface with a soft core which is of considerable advantage from the point of view of wear and mechanical strength. The connecting rod is made of steel and is provided at one end with an adjustable brass bearing for the pin and at the crank pin end with a so-called marine head, the brasses of which are filled with white metal. The shaft is cranked and sits in annular lubricated bearings with white metal bushings. In small compressors, these bearings are made in two parts and equipped with a loose ring. In large units, they are in four parts and equipped with ring lubrication, with self-adjusting rings.

The air is cooled by water, the valve chamber being cooled as well as the working cylinder, and in the intermediary cooler, water cooling is also used. The cooling water passes through the pipes around which moves in countercurrent the air to be cooled, baffles being provided to force the air to move in an indirect path around the pipes.

Fig. C shows the arrangement of the valve gear. Since the flowing air can produce only quite a small pressure on the valve discs, it has been found possible to limit the motion of the valves to the utmost, as a result of which the valve lift could be also maintained quite small. On the other hand, in order to provide a sufficient cross section of flow, ring valves had to be used. Each ring is held against its seat by a spring and the spring (2, Fig. C) is so adjusted that the movement of the valve corresponds exactly to that of the piston. Since the speed of the piston compressor driven by a belt cannot be closely regulated in the present design, the amount of air sucked in is regulated by a separate valve gear, which permits the unloading of the compressor when the air tank is full. If the demand for air increases, the compressor is automatically placed on load again. One design of such a valve gear is shown in Fig. D. It is automatic and regulates the air admission by means of a cut-off. As soon as the pressure in the air tank exceeds a certain maximum, the apparatus lifts the suction valve and permits the air taken in to return into the section chamber. When the pressure in the air tank goes down, the suction valve is again released. There is provided a special device, however, to regulate the compressor by hand. In addition to this, further regulation is secured by equipping the flywheel with an electro-magnetic coupling; when the tank is full, the compressor is automatically set at rest while the flywheel is allowed to run.

The original article contains a table showing the efficiencies, outputs and approximate dimensions of the present machine. (*Ein neuer zweistufiger Einzylinder-Kompressor, Der praktische Maschinen-Konstrukteur,* vol. 48, no. 13/14, p. 61, April 8, 1915, 3 pp., 6 figs. *d.*)

Internal Combustion Engineering

"UTO" TWO-STROKE CYCLE ENGINE

A continuation of an article describing internal combustion motors at the Swiss National Exposition in Bern, in 1914. The present abstract is devoted to the description of the two-cycle "Uto" engine built by the Iron Foundry M. Koch, Zurich, Switzerland.

This engine, built in 4, 10 and 24 h.p. units, appears to be of very simple design. The compression of the scavenging air is effected in the crank case, from which the air flows through slots in the piston and jacket onto the upper end of the cylinder and in this way drives out the residues of combustion through the exhaust ports. The grid valve which admits the air into the crank case has spring steel plates of rectangular cross-section.

The cylinder cover shown in a simplified sketch in Fig. 2A, is semi-spherical designed like a charge cover, but does not have to be maintained in a glowing state in order to cause self-ignition of the charge. In its upper part, the cover is provided with water cooling which protects the material from overheating. This water enters by pipe *L* into the chamber *E*, falling directly on the fuel nozzle *D* and in this way keeps it cool. The water flowing out of *J* is led to the exhaust funnel *K*, designed like an injector. The major part of the cooling water in the cylinder jacket passes through the nozzle into the outflow in order to operate the injector, while the rest of it, because of the suction produced at *J* by the injector, is lifted into the chamber *E* by the pipe *L*. This peculiar method of cooling (and with it the time of ignition) can be regulated, in accordance with the load, by the cock *G*. Of special interest in this connection is the fact that no water is injected into the interior of the cylinder. The fuel oil pump *B* is regulated by a shaft governor which varies the stroke.

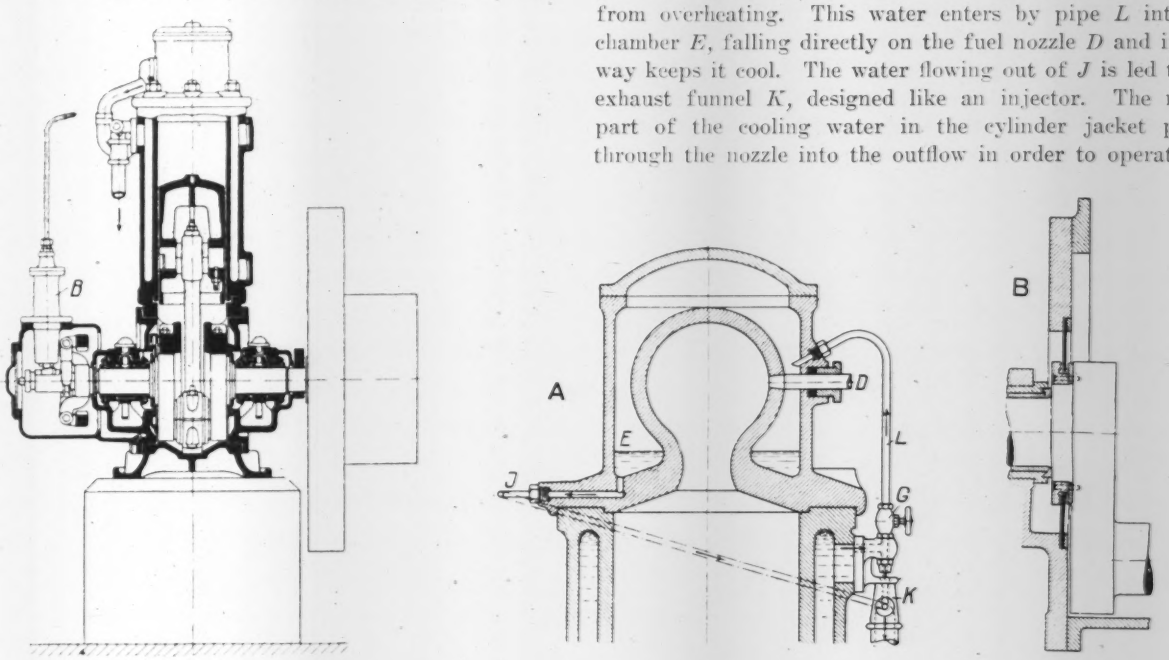


FIG. 2 "UTO" TWO-STROKE CYCLE ENGINE

In order to make the main bearing fully accessible, the crank space is provided with a patent method of packing (Fig. B) in which a lower membrane is alternately pressed slightly against first one and then the other side of a circular groove. This arrangement permits the equipping of the bearings with ring lubrication and at the same time makes the cover removable.

The author carried out on such a motor a series of brake tests in which he used crude oil of specific gravity 0.87 and obtained the following values:

Rev. per min.....	305	306	307
Effective brake output, h.p...	24.9	17.25	12.35
Fuel per effective h.p.h., g/lb.	242/.532	248/.545	273/.600

(*Die Verbrennungsmotoren in der gruppe 32 an der Schweiz. Landesausstellung Bern 1914*, Professor P. Ostertag, *Schweizerische Bauzeitung*, vol. 65, no. 15, p. 165, April 10, 1915, 2 pp., 3 figs., article not finished, *d*.)

Railway Engineering

Fireless Locomotives

The advantages of the fireless locomotive lie in its unquestionable safety with respect to fire, which makes it extremely convenient for use in factories handling explosive materials and in gas works, as well as in various classes of chemical manufactories. The attendance is extremely simple because of the absence of the usual boiler, with its attendant necessity of watching the fire and water level. Also, since the pressure in the steam container cannot exceed a certain definite amount, it is not necessary to watch constantly the gage and one man can very well take care of even a large fireless locomotive, devoting practically his entire attention to the road. The water container of the fireless locomotive is almost free from scale and the repairs must be very low because of the absence of all the most sensitive parts of an ordinary locomotive boiler, such as the fire box, staybolts, fire tubes, etc.

A fireless locomotive which has been used for $2\frac{1}{2}$ years in the works of the Hannover Machine Company cost only 50 marks ($12.50) in repairs in that period, during which time it was used not only in the plant itself for switching work, but was also several times loaned to other works in the neighborhood. It is considered that a depreciation of 7 to 8 per cent per year is entirely sufficient because of its long life. It has, of course, its disadvantages, and can be used neither for trunk line service, as the author shows by detailed calculation, nor for the handling of heavy loads. Its field is apparently in switching service and hauling loads inside the factory limits.

The article gives in detail the calculation of the water tank as a heat reservoir. A brief bibliography is appended (*Feuerlose Lokomotiven*, G., *Rauch und Staub*, vol. 5, no. 5, p. 73, February 1915, 10 pp., 11 figs. *dp*).

Wrought Iron in Locomotive Fireboxes, G. Hammer

Discussion of the application of wrought iron in the manufacture of locomotive fireboxes.

Up to the time of the present war, railroads in Germany were very large consumers of copper. A very large amount of secondary equipment, such as door handles, hand rods, etc., as well as all brasses, were made of copper alloys, while fireboxes, stay-bolts and locomotive tubes were made of pure copper. This was due to the fact that experiments with the introduction of wrought iron fireboxes did not turn out satisfactorily some years ago, and it was there found that although the first cost of installation of a copper firebox was several times that of the iron firebox, it paid in the end. In the first instance, because the depreciation of the copper was quite insignificant and the remelted firebox returned practically the original value in metal. In addition to that, copper is easily worked, does not rust, is little subject to burning and easily permits the tightening of joints and stay-bolts.

Of late, however, even in Germany, several circumstances tended to equalize this relation in favor of the wrought iron firebox. The main fact was the rapid increase in size and operating pressures of modern locomotives. This led to a considerable reduction in the life of a copper firebox, first because the great increase in temperature materially reduces the strength of copper and next because its coefficient of expansion is greater than that of iron, so that, in the long fireboxes, there is a greater tendency towards bending, and consequently greater frequency of ruptures.

The conditions of locomotive operation have also changed in favor of the iron firebox which is particularly liable to suffer from rapid and sudden cooling: locomotives are now worked on two and three shift schedules and therefore they are less time out of service. Further, they are now nearly always washed with hot water, which affords better protection than washing with cold water.

The author believes, therefore, that there is a good chance for the introduction of wrought iron fireboxes on locomotives in Germany. (*Ueber die Verwendung von Flusseisen zu Lokomotivfeuerbuchsen*, Gustav Hammer, *Glasers Annalen für Gewerbe und Bauwesen*, vol. 76, no. 907/7, p. 129, April 1, 1915, 2 pp., *g*.)

Refrigeration Engineering

Ammonia Explosions in Refrigerating Plants

The author discusses the question as to whether ammonia explosions do actually occur in refrigerating plants.

In particular, he refers to a case of an explosion in a German refrigerating plant, which was ascribed to the decomposition of ammonia in the compressor cylinder and the penetration of the gases into the engine room. This case led to the investigation by the Institute of Physical Chemistry and Electro-chemistry of the Technical High School at Karlsruhe, by S. Schlumberger and W. Piotrowski, who introduced into a bell-shaped glass vessel, 110 mm. (4.33 in.) in diameter, mixtures of ammonia and air in various proportions and ignited them by an electric spark. It was found that a mixture of air with from 16.5 to 26.8 per cent by volume of ammonia violently exploded in the glass vessel, but that with the ammonia content above or below these limits, no explosion took place. Comparative tests with a tube-shaped vessel have given a slower combustion, due probably to the cooling action of the walls, the region of explosibility being limited to from 19 to 25 per cent by volume.

Refrigerating engineers are, however, interested principally in the question whether conditions such as have been shown by this experiment, and which produce explosibility of ammonia and air mixtures, can actually occur in practice. It is hardly likely that under ordinary conditions, 16 to 20 per cent by volume of ammonia can mix with the air, but that may, of course, occur in exceptional cases, for example, when a defect develops in the operation of the machinery, a rupture of a pipe occurs, or something like that. In the case referred to above, a branch pipe broke and allowed ammonia to flow out. The fireman, who was burned about the face and hands, claims that he heard an explosion and saw a flame. As there was a gas burner in the engine room, the assumption naturally was that an explosive mixture of ammonia and air took fire from the open flame.

However, the author doubts this, because the conditions under which the actual explosion occurred did not coincide with the conditions which were present when the tests were carried out. In the latter case, ignition was caused by an electric spark, and, because of the shape of the vessel, prop-

agated with considerable velocity. It is by no means proved that an ignition could likewise occur from an open gas flame and that the combustion in free air would occur in the same manner as in a closed experimental bomb. As a matter of fact, the author doubts that there was any explosion at all in this case, in the sense of a sudden combustion of a mixture of gases, and he supports his contention by reference to another accident where ignition of ammonia by a gas flame appears to be fairly well established. According to a report of the German Slaughterhouse Paper (*Deutsche Schlacht- und Viehhofzeitung*, November 15, 1914, p. 574), in November, 1914, there occurred in the engine and boiler room of the Municipal Slaughterhouse, at Elbing, a fire due to a rupture on a compressor and ignition of the escaping ammonia by an open gas lamp. It appears that in this case a screw on the compressor piston worked loose and fell between the piston and cylinder cover so that during the return stroke of the piston the cover was fractured. No explosion occurred, but there was a strong fire, which destroyed the roof of the house.

Mr. A. Behr, in a Report to the Sixteenth Annual Meeting of the Association of German Inspection Engineers (Verhandlungen der 16. Hauptversammlung des Vereins Deutscher Revisions-Ingenieure), read a paper on the "Decomposition of Ammonia in Ice Machines," where he mentions a grave accident in the brewery of the Hildesheim Brewery Company, in which case an ammonia compressor was started with the exit valve in the pressure piping closed. As a result, the cylinder was brown up by the increasing pressure. Immediately thereafter, the entire engine room, which was lighted by gas, was enveloped in a sheet of flame. In another case, in a Berlin brewery, rapid ignition took place when a fire was brought near an open ammonia compressor. According to the opinion of Mr. Behr, this accident was due not to the combustion of ammonia and air mixture, but to the ignition of hydrogen which formed in the engine through the decomposition of ammonia, which decomposition, in its turn, was due to rise of pressure and temperature of ammonia caused by starting the compressor with a closed pressure valve.

That this decomposition does take place was shown by the experiments of Doctor Mohr, who has found in three instances a high content of free hydrogen and nitrogen in experimental compressors. For practical purposes it would be desirable to carry out a theoretical and experimental investigation which would show whether decomposition of ammonia actually takes place, and if so, how it can be prevented. (*Zur Frage der Ammoniakexplosionen*, G. Cattaneo, *Zeits. für die gesamte Kälte-Industrie*, vol. 22, no. 1, p. 3, January 1915, 2 pp., *pe*).

Steam Engineering

Oil Separation from Water of Condensation

The article describes a method of separating oil from water of condensation, such as is applied in Germany in mine plants and large engine houses.

Where there is a large number of engines, the author recommends leading the water of condensation to some deep well (Figs. 3A and B), arranged in such a manner that it is divided by the walls *d* into three large compartments, *a*, *b* and *c*. Into one of these compartments the water of condensation, rich in oil, is allowed to flow, and is then led through the several pipes *e* from the deepest part of the well into the second compartment, whence it passes into the third compartment, and is finally delivered to where it belongs by the centrifugal pump *f*, having its suction point at the deepest part of the well.

Since the water of condensation is still so hot that it cannot be taken up by the pump with a high suction head, the pump is located in the shaft *g* close to the collector well in such a manner that it is below the water level of the third compartment. In order that the third compartment would not be drained if its inflow should happen to be lower than the delivery of the pump, there is provided in the suction piping a throttle valve *h*, with float *i*, maintaining the water level in that section always at the same height. The third section is further provided with an outflow port *k* (leading into the sewers), the purpose of which is to prevent the well from being flooded in case of the pump stalling, or of

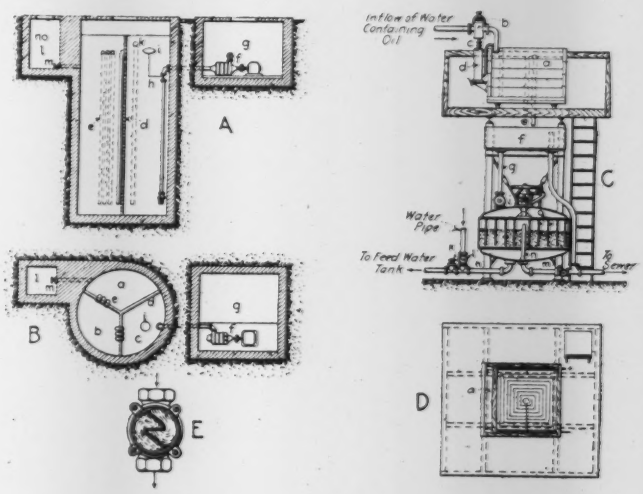


FIG. 3 PLANT FOR SEPARATION OF OIL FROM WATER OF CONDENSATION

excessive influx of water. This outflow is located at a point much higher than the suction piping, and is connected by a pipe with the bottom of the well, so that all outflow water should be as free from oil as possible. To permit of the cutting out of the entire plant for purposes of cleaning or repairs, the water of condensation, rich in oil, coming from the various sources, is led into a small collector well *l*, located in front of the first section; this well way be cut off from the first section of the tripartite well by means of a valve *m*. When this valve is closed, the water is discharged directly into the sewer pipe by an exit port *n*, located at the higher level.

When the water of condensation is admitted to the well, the oil in it is in a state of either drops or emulsion. In the well, when the water is in a state of rest, the oil in drops separates because of the different specific gravity, and can be easily collected on the surface of the water. This oil is pure because of the heavier impurities having settled down to the bottom of the well, and can, therefore, be again used for cylinder lubrication. If, however, the water of condensation is intended for use as boiler feed water, it must be freed also from the oil in the state of emulsion, and this can be done electrolytically, for example, by means of the apparatus shown in Figs. C and D (Reubold electrolytic oil separator).

The water, rich in oil, is supplied by a centrifugal pump, above referred to. It first passes through chamber *a*, where it is led between the worm-shaped electrodes, the separation of the oil taking place under the action of the electric current. Since, however, the water of condensation, apart from the oil it contains, is nearly chemically pure, it is a very bad conductor of electricity, and the device would not work at all unless this resistance were previously decreased by some means. In this case this is done by the addition of a solution of soda. In the supply piping is built in a vessel *b*, out of which, through a throttling valve *c*, the soda and water for this solution are supplied to the tank *d*. After the water of condensation has passed through between the electroids, it flows, together with the oil, which is now separated in the form of flakes, through pipe *e* into the collector *f*, provided with an overflow, and thence through pipe *g* into the gravel filter. Here all the oil particles are separated from it, and the pure water flows through pipe *h* into the reserve tank.

From time to time, in accordance with the load which the oil separating installation carries, it is necessary to wash the gravel in the filter. To do this, valves *i* and *k* are closed and valves *l* and *m* are opened. Pure water flows in through valve *l*, forces for itself a path through the gravel and floats the oil particles to the surface, whence, through stand pipe *n*, they pass into the discharge piping. In order to increase the efficiency of washing of the gravel, the contact device *o* is rotated by a hand crank in smaller installations and by an electric motor in larger sizes.

For 1 cbm. (35.3 cu. ft.) per hour, approximately 0.2 kw. direct current are necessary, which means that at the price of 2 pfennigs (½ cent) per kw. hr., the cost of electric purification amounts to less than ½ pfennig per cbm. The plant works entirely automatically, and the attendance is limited to cleaning the filter at regular intervals and taking off the oil collected from electro-deposited emulsion on the surface of the water in the chamber *a*. It is advisable to locate the plant at such an elevation that the water of condensation coming from the gravel filter will flow into a feed water tank located at an equally high elevation. This arrangement is particularly advisable where centrifugal pumps are used for supplying boiler feed water, because purified water is still quite hot. Such pumps work at their best where the water is supplied to them by gravity.

In a different connection, the same article describes what the author calls a device for inspecting steam traps. This device, shown in Fig. E, is built in such a manner that the water or steam, flowing under the glass, is forced to change its direction twice, which enables one to see clearly through the glass, whether it is water or steam that is flowing, or whether there is no flow at all. (*Gewinnung von öl und ölfreiem Kondensat aus Abdampf*, M. Vahle, *Glückauf*, vol. 51, no. 17, p. 409, April 24, 1915, 4 pp., 6 figs. *d*).

ENGINEERING SOCIETIES

AMERICAN INSTITUTE OF MINING ENGINEERS

Bulletin, no. 101, May 1915, New York City

The Mellen Rod-Casting Machine, R. C. Patterson, Jr. (abstracted)
The Electric Furnace in the Foundry, William G. Kranz
Method of Making Mineralogical Analysis of Sand, C. W. Tomlinson
Cost Factors in Coal Production, William H. Grady

THE MELLEN ROD-CASTING MACHINE, R. C. Patterson, Jr.

Description of the Mellen rod-casting machine, introduced by Grenville Mellen to take the place of the present system of producing rods of zinc, brass, copper and aluminum.

The new process consists in the production of cast rods in one operation in a small continuous casting machine. The hot liquid metal is transferred from the molding crucibles directly into an endless chain of molding blocks in the machine, where solidification takes place and the rod comes out continuously in solid form from one end as long as the molten metal is supplied. The operation of these small blocks, so as to produce a solid rod of uniform structure, constitutes an important part of the process.

The article describes in detail the machine shown in Fig. 4. It is 12 ft. in height over all, 2 by 3 ft. in horizontal

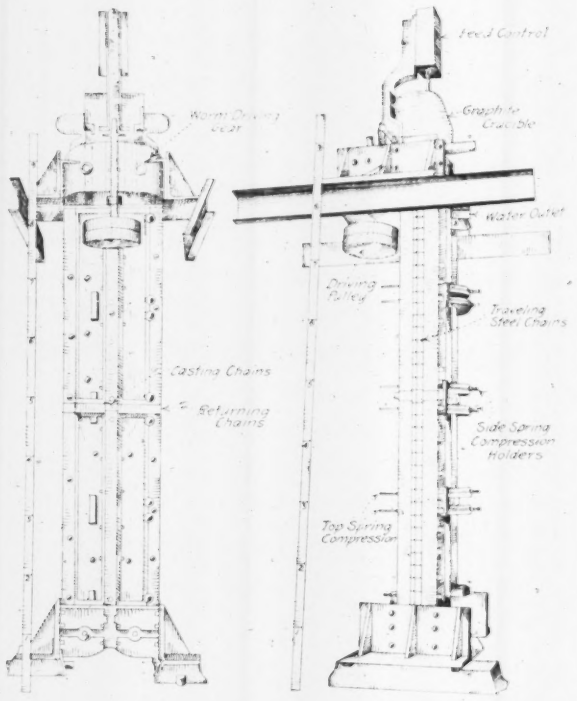


FIG. 4 MELLEN ROD-CASTING MACHINE

cross sectional area and weighs 6000 lb. A cast iron frame work holds in position two endless chains of molding blocks, which are made in sections and joined in center alignment. The mold orifice is made up of these mold sections into which the liquid metal flows. The accuracy of alignment, requisite for the production of a perfect rod in the groove formed by these sections, is secured by careful machine work and by building the four ways, down which the alignment takes place, so that two of the sides are fixed permanently while the opposite sides are held to their position by spring pressure. The guides carrying the molds while in casting position are water-cooled square tubes. The length of the machine is indeterminate; a certain amount of both time and cooling surface is required to solidify the metal in the mold and one may use either a long molding chain and run it fast or a shorter chain and run it slowly. The machines may be either vertical or horizontal.

The flow of metal into the machine is controlled by an electrically operated automatic device which adjusts the feed

to the speed at which the machine is operated. If for any reason the machine should stop, the flow of metal would also be automatically shut off. If any foreign material clogs the chain, a safety pin is thrown to protect the mechanism from injury. The rods are delivered from the machine immediately to the die of a bull block, which turns them down to suit particular orders. The advantages of the machine are simplification of manufacture, elimination of loss from oxide scaling during the heating and rolling, and elimination of danger to human life—the latter because the apparatus is completely enclosed and the operator is protected from injury.

The article describes also a continuous casting machine for making rods of lead and soft metal alloys ¼ in. and upward in diameter. The author states that the machine's operating cost is less than 30 cents per ton of molten metal cast into the form of rods (7 pp., 4 figs. *d*).

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Journal, vol. 21, no. 1, April 1915, New York City

Measurement of Air Flow, Arthur K. Ohmes (abstracted)
Pipe System for Water Heating, Professor F. E. Giesecke
Apparatus for the Study of Heat Radiation, Professor J. D. Hoffman

MEASUREMENT OF AIR FLOW, Arthur K. Ohmes

Description of various apparatus used for the measurement of air flow. Discussion of their advantages and disadvantages and field of application.

The author divides all instruments for the measuring of the flow of air into seven classes, which he considers preferable to the division into so-called volumetric and pressure measuring instruments because of the intimate relation existing on some instruments between volumetric and pressure conditions.

The precision of measurements in heating and ventilating has notably increased during the last two decades. Fifteen years ago engineers were satisfied to be able to read a column of water accurately within one-tenth of an inch. Five years ago, one-hundredth of an inch was considered an accomplishment; while today instruments are available with which one-thousandth of an inch of water can be measured. The same applies to air measurements. Ten years ago, measuring an air current at a velocity as low as 1 ft. per second was approximately the limit, whereas today a current of air of less than one-tenth of a foot per second can be measured with fair accuracy. The author believes, however, that the limit of exactness in this field of measurement has by no means been reached.

Various types of meters, anemometers, Pitot tubes and devices for measurement by adding heat to the air are described, as well as long distance and centralized air measurement gages, and the micromanometer. These descriptions are not suitable for abstracting. The common fly-wheel anemometer is not suitable for air velocities below 2 ft. per second because the work done by the air to overcome friction is, at low velocities, lost for measuring the air current itself. If, however, the frictional losses in measuring air current are compensated for (as in the apparatus described by the author), an anemometer can be used for the lowest air velocities.

As regards Pitot tubes, the author believes that the ultimate Pitot tube that should be accepted as a standard the world over need not be one with a correction factor of unity (like the Prandtl tube), and may have any, or even a large, correction factor, if constant, for any and all velocities, provided the slight deflections of the tube will not vary the results for velocity and static pressures. He believes, however, that except when both great accuracy and integrity prevail in making the test (as in laboratory or small apparatus factory tests), it is difficult to expect much consistency in air measurements with Pitot tubes. The author strongly insists that in any case, in order to secure uniform results, the most accurate instruments are necessary, and that the greatest care and integrity of purpose is required. (23 pp., 26 figs. *d*).

COLLEGE OF ENGINEERING, KYOTO IMPERIAL UNIVERSITY

Memoirs, vol. 1, no. 2, February 1915. Kyoto, Japan.

Tests on the Combined Bending and Torsional Strength of Cast Iron, Tsuruzo Matsumura and Genjiro Hamabe (abstract)
Beiträge zur Theorie der Elastizität gekrümmter stabformiger Körper, Tsuruzo Matsumura.

TESTS ON THE COMBINED BENDING AND TORSIONAL STRENGTH OF CAST IRON. Tsuruzo Matsumura and Genjiro Hamabe

The paper investigates the elastic behavior of cast iron under combined bending and torsional stresses.

Recent experiments on elastic failure of mild and harder steels show results not in close conformity with the principal stress theory of Rankin or the principal stress theory of St. Vénant. They rather support the hypothesis proposed by Mohr in 1900, which may be stated as follows: "Elastic failure of ductile material or the breaking of a brittle material takes place when the shearing stress, acting at the point along a certain plane, attains a limiting value which is a function of the normal stress at that point." As regards the combined strength of a brittle material like cast iron, little is known, which was the incentive for the experiments carried out by the writers.

The testing machine was designed in conformance with the principle of Croker's testing machine. The test piece was made of the form and dimensions shown in Fig. 5A. The diameter d was taken as $^{11}/_{16}$ in. for ordinary cast iron and $^{5}/_{8}$ in. for high grade cast iron. All the test pieces in a single series of tests were cast in one charge. Fig. B shows the method of molding for Series 1 and 2 and Fig. C, that for Series 3 and 4. In the tests, the writers determined the bending moment and torsional moment for various pieces, calculated the constants and the bending strength for each series of cast iron by the method of least squares, and gave a series of curves of which only Fig. D is here reproduced, as representing the law of combined strength corresponding to the equation

$$M_o = (1\text{-}A)M + A\sqrt{M^2 + T^2}$$

where M is the moment of bending, T the torsional moment, A a constant and M_o the equivalent bending moment; that is $M_o = \frac{\pi}{32} d^3 K$ if d is the diameter of the rod subjected to the combined action and K, the bending strength (elastic bending strength for a ductile material). It was found that the St. Vénant theory applies to cast iron in the most satisfactory manner. A plate is given showing the forms of fracture for one of the series of tests. Attention is called to the

fact that as the ultimate torsional moment is greater, the section of fracture is more inclined toward the plane normal to the rod axis (8 pp., 10 figs. *e*).

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Proceedings, vol. 31, no. 1, February 1915, Pittsburg, Pa.

Tests on a Recent Type of Chain Grate Stoker and New Method of Baffling Stirling Boilers, John A. Hunter (abstracted)

The Relation of Educational Training to the Practice of Engineering, William H. Burr

TESTS ON A RECENT TYPE OF CHAIN GRATE STOKER AND NEW METHOD OF BAFFLING STIRLING BOILERS, John A. Hunter

The installation (Vandergrift Works of the American Sheet & Tin Plate Company) on which these tests have been made, consists of seven class M-22 Stirling boilers nominally rated at 600 h.p., containing 6032 sq. ft. of water heating surface and 396 sq. ft. of super heating surface. For draft it has an individual unlined steel stack 72 in. in diameter and 150 ft. high above the breeching. Each boiler is provided with one type "L" Green Engineering Company stoker, 10 ft. 6 in. wide by 12 ft. long, containing 126 sq. ft. of chain surface, the initial tests having been undertaken to determine if the guarantees made for the stokers could be met. During these tests, the baffles were arranged as shown in dotted lines on the drawing Fig. 6A and the openings at the end of the baffles were according to the dimensions in the circle. In place of the pressure water-back there was a single pipe supplied with low pressure water. These tests indicated that the efficiencies obtained were below the guarantee.

To meet this condition, the baffles were changed as shown in solid lines on the drawing and a special water-back was installed with two separate water boxes placed one directly over the other and each one connected to the mud drum and front steam drum, thereby insuring positive circulation throughout the box. All tests were conducted according to the Code of The American Society of Mechanical Engineers (the procedure is fully described in the original paper).

For tests numbers 180-182, the gate was about 6¾ in. above the pusher and in tests 183-189 the gate was about 7½ inches above the pusher; after test 182 a change was made in the manner of operating the stoker designated as the "slow-chain" method of operation to distinguish it from the old method of "fast-chain." The slow-chain operation was used on the rest of the tests. In diagram B, the area under the dotted lines shows the character of the fuel bed with the fast-chain method of operation. The depth of the fuel bed is about the same over the entire grate except near the water-back, where it is piled up. The character of the fuel bed with the slow-chain method of operation is shown by the solid line on the diagram. Here the fuel bed is quite deep on the front part of the stoker and gradually thins out until it is about the same depth as the fuel bed of the fast-chain operation, with the exception of a point about 3 ft. ahead of the water-back, where it is also piled up.

With the fast-chain method, the distillation of the volatile gas of the coal takes place very rapidly and a large portion of it passes off in the flue gases and is burned, which is evidenced by the amount of smoke observed. The coal does not remain on the grate a sufficient length of time to have its carbon content completely burned. With the slow-chain method, the distillation of the volatile gas takes place quite slowly. All this gas is driven off by the time the thin portion of the fire is reached, and as there was practically no smoke except at very low ratings, it is thought that practically all the volatile gas is burned. The thin portion of the fire allows an excess of air to be drawn through the fuel bed at this point, which completes the combustion of the carbon.

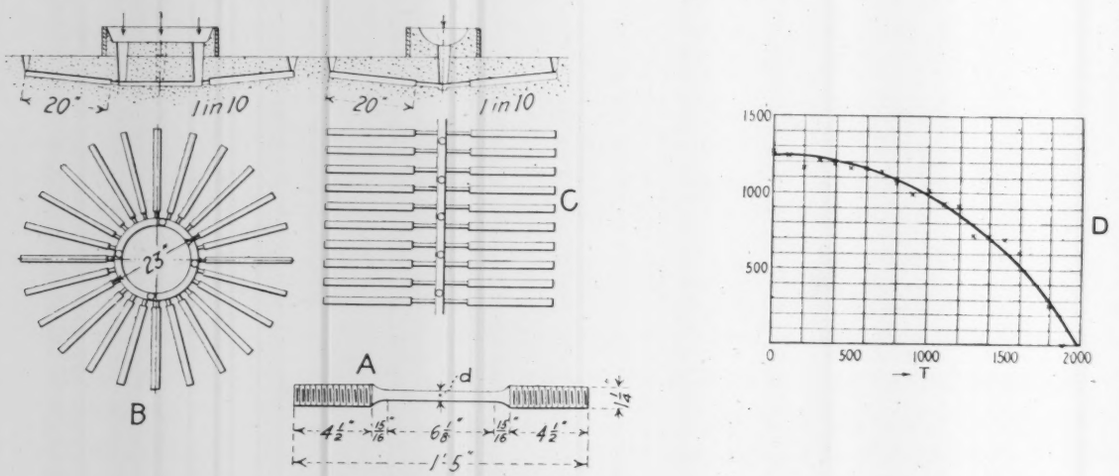


FIG. 5 METHODS OF MOLDING TEST-PIECES FOR TESTING THE STRENGTH OF CAST IRON

A number of tables are given showing the results of the tests. From these tables, it is seen that efficiencies from 67.7 to 79.8 per cent and capacities from 74 to 195 per cent of rating were obtained. In regard to the percentage of combustibles in ash, it varies with fast-chain firing from 33 to over 44 per cent, while with slow-chain, it was maintained around 23 per cent and in one case went as low as 17.86 per cent. The flue gas temperatures with fast drive vary from 520 to 617 deg. and with slow drive from 417 to 550 deg., but excluding two cases of exceptionally high flue gas temperature, the average for the slow-chain method was around 450 deg., or apparently very much lower than with the fast-chain. The loss due to radiation varied from 2.55 to 5.70 per cent, with an average of 400 per cent for all the tests.

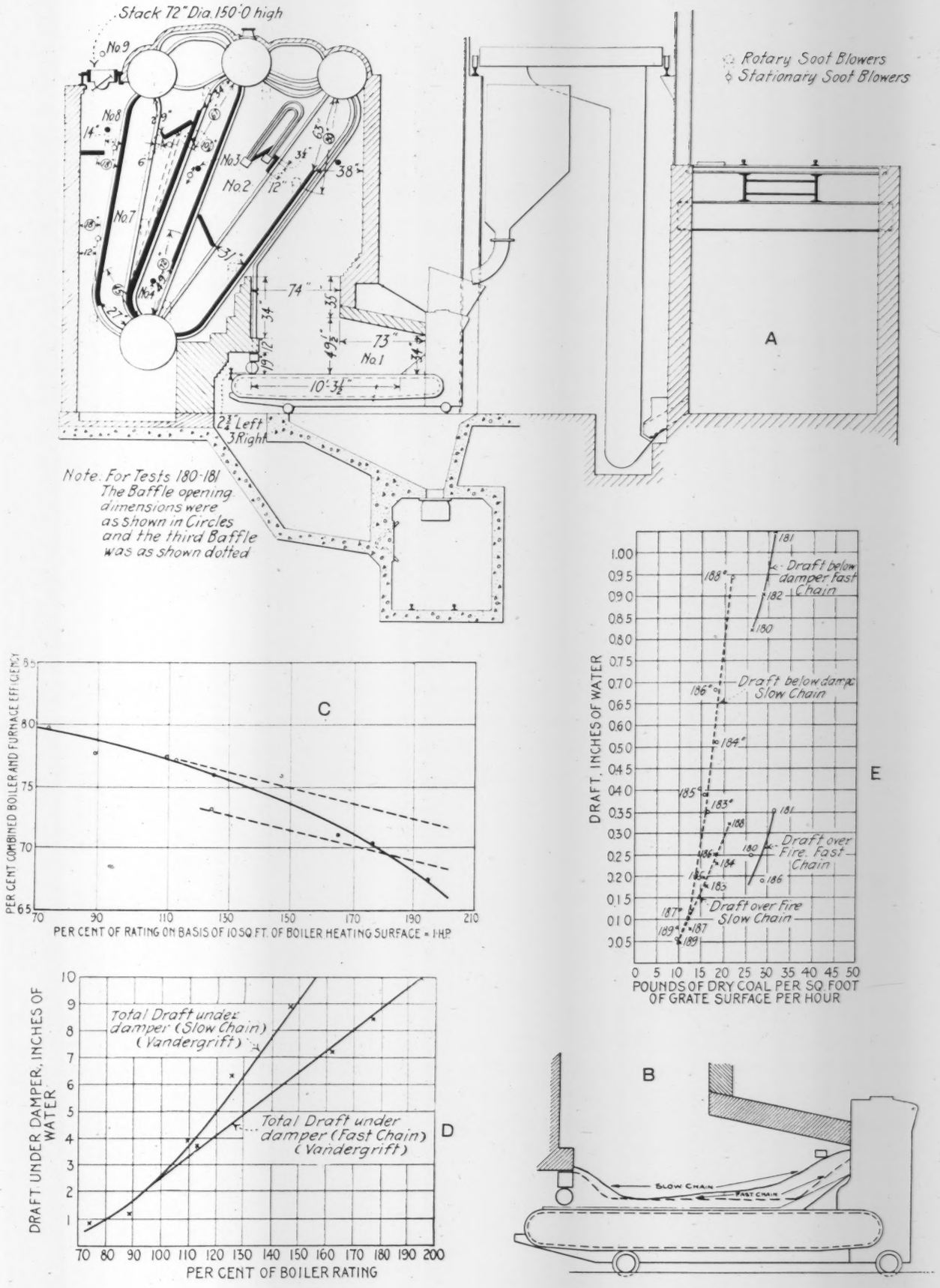


FIG. 6 NEW METHOD OF BAFFLING STIRLING BOILERS; "SLOW CHAIN" METHOD OF FIRING

The uniformity of these results would tend to indicate that no appreciable error has been made in taking the data.

Curve Fig. C shows the relation between the percentage of boiler rating and combined boiler and furnace efficiencies. The curve shown in solid lines refers to the actual efficiencies obtained from all the tests. The points below 150 per cent capacity are for the tests run with slow-chain method and points above 150 per cent capacity are for the fast-chain method, about 150 per cent of rating capacity being the maximum which can be obtained from this boiler with the slow-chain method of operation; so that when capacities above 150 per cent were desired, it was necessary to increase the chain speed and change the operation to approach the fast-chain method.

By taking indicator diagrams from the engine driving the stoker, it was found that it required an average of 0.72 i.h.p. to operate the stoker. Allowing 80 lb. of steam per horse power hour, the following percentages of steam generated are required for the operation of the stoker: at 100 per cent rating, 0.35 per cent; at 150 per cent rating, 0.23 per cent; at 200 per cent rating, 0.17 per cent. Quantities so small that for all practical purposes the efficiencies obtained can be considered as net efficiencies.

In the discussion which followed, D. S. Jacobus stated that, in his opinion, the striking feature of the tests is the gain in efficiency due to the use of the slow-chain method as compared with the fast-chain. The heat balances show that this was due to a more perfect combustion and better ash. The lesser amount of smoke produced with the slow-chain method is also an item favoring efficiency. It is usually best to make an investigation of the method of operating furnaces rather than perfunctory tests and to depart considerably from what may be considered standard practice, in order to get the results. The speaker was present at one of the tests and was impressed with the great care which was exercised to secure accurate results.

John Wolff, of the Cleveland Electric Illuminating Company, stated that for some months past the station of his company was operating in a somewhat similar manner. It was found that for ordinary everyday operation, fixed conditions of fuel feed could be established and required no change from one month's end to the other, and that with these conditions established, it was possible to take care of momentary variations of load by simply manipulating the dampers. For peak work the speed of the chain only is increased, which is done by changing the chain feed from two to three teeth of the ratchet. With these manipulations a uniform steam pressure could be maintained as well as water level with little or no fluctuation, requiring few adjustments of the feed valve. One of the most important advantages of such a system is the extreme confidence which the operators feel in their ability to meet and handle all situations.

W. E. Snyder, of the American Steel and Wire Company, Pittsburgh, called attention to the fact that the determination of the efficiencies of boiler and grate depends on the knowledge of the correct heating values of the coal, as a high over-all efficiency may be obtained by ascribing to the coal a low heating value and showing the heat lost up the stack and to the ashpit as less than it actually was. From this point of view, the speaker, while believing that there may be a wide variation in the heating value of the coal obtained from the same mine, calls attention to the fact that as shown by the paper, the heating value of the dry coal obtained from the same mine varied from 12,900 to 13,616 B.t.u. per pound. He recalculated the results in one of the tables, using the heating value of the coal given and the ash by analyses of the coal, and found that the average heating value per pound of combustible is 15,120 B.t.u. with a minimum of 1.1 per cent below the average and a maximum of $^2/_3$ of 1 per cent above the average, giving a close and consistent agreement among the samples. With the ash in the coal as determined by analyses, it can be used to check the quantity of refuse from the ashpit and its analysis. The author prepared a table by taking the total percentage of ash refuse that went to the ashpit and multiplying it by the percentage of incombustible matter which it contained. This gave a new percentage, which is the incombustible matter in the coal as determined by the analyses of the refuse from the ashpit. On the whole, he found that the ash in dry coal as determined by analysis of ashes from the ashpit is equal to 11.10 per cent and the average of the ash as determined by chemical analysis of the coal is 11.70 per cent, or a difference of 0.6 of one per cent, this difference being in the right direction, as the coal analysis should give a slightly higher ash because of some of the fine ash being carried out from the furnace over into the boiler and not being taken out of the ashpit. While in this manner a close constant agreement of data of ash content is secured, it is not possible to have an equally satisfactory check on the quantity of heat lost up the stack because the nature of the data does not permit it.

M. Alpern, of the American Engineering Company, Philadelphia, believes that an improvement can be expected in boiler maintenance through the elimination of the Stirling arch. The speaker referred to tests conducted at the Detroit plant on a five pass specially baffled Stirling boiler. Fig. D illustrates the total draft in the case of the Vandergrift specially baffled boiler with slow-chain and fast-chain method of operation. From these curves, it would appear that the limit of the available draft with the slow-chain operation was reached at approximately 155 per cent of rating, whereas the fast-chain method obtained a considerable higher rating. The Vandergrift boilers were operated at 125 lb. pressure. Additional data on the same boilers were supplied by T. A. Marsh of the Green Engineering Company of Chicago. The coal used at Vandergrift contained on an average 1000 B.t.u. less per pound than the coal used in Detroit and nevertheless the percentage of combustible in the ash at Vandergrift during the slow-chain tests was lower than that of the well known Edison plant at Detroit, although the furnace at Vandergrift is not as large as the one at Detroit and probably the combustion of the hydrocarbons was not as complete. On the other hand, the heat loss, due to radiation, was certainly higher at Vandergrift than at Detroit, due to the difference in the size of the units. T. A. Marsh has further prepared curves (Fig. E) showing the combustion rates per unit of draft obtained with the fast-chain method as compared with the slow-chain method. With the fast-chain method the combustion rate of 30 lb. of dry coal per sq. ft. of grate surface per hour, using a furnace draft of 0.30 in. water column; with the slow-chain method, the same draft was used for a combustion rate of only 21 lb., with the draft below the damper in both cases 0.90 in.

The speaker summarized the differences in results obtained

by the slow-chain method as follows: *a*. For the same combustion rate, a chain speed of less than one-half; *b*. A furnace draft of much greater intensity; *c*. Lower flue gas temperatures; *d*. Lower percentage of combustible in the ash; *e*. Higher percentage of Co_2; *f*. Practical elimination of smoke; *g*. Increased capacity due to increased efficiency at a given combustion.

Certain objections to the views and methods of Mr. Hunter were expressed by A. A. Straub, of the Duquesne Light Company, Pittsburgh. He considered the efficiencies obtained too high, and expressed the opinion that in this case efficiency has been obtained at the expense of flexibility in operation. He gave a diagram showing that the efficiencies decrease rapidly with increased percentage of rating contrary to the case in the Delray tests with under-fed stoker, where higher ratings were obtained.

J. E. Bell pointed out that the baffle at Vandergrift was not designed to produce a minimum draft loss or to absorb the maximum amount of heat from the gases; and it would appear that in this particular it answers the purpose. If a greater capacity should be required from a boiler with this baffle, the draft available at the damper must be increased by an amount corresponding to the rule that, at higher ratings, the draft loss is almost directly proportional to the square of the capacity, and to that should be further added the amount necessary to burn the additional coal.

In answer to questions, the author stated that no particular effort was made to prevent radiation, the brick work of the boiler not being covered with heat insulating material. As regards the efficiency curves shown by A. A. Straub, comparing data obtained at the Vandergrift tests with those obtained from tests made of the boilers in the Delray station of the Detroit Edison Company, the author pointed out that efficiencies obtained from chain grate stokers ought not to be compared with those from forced blast underfeed stokers without making a correction for the power required to operate the stokers. To this he adds the Table 1, showing the comparative efficiencies between the two sets of tests, the net efficiency with the slow-chain operation being slightly higher than those of the Delray tests, although it is true also that in some cases part of the steam which is required for the operation of the stokers can be recovered in the feed water heater.

The subject of determining the moisture in the coal brought up an extensive and interesting discussion, which cannot be reported here because of lack of space. (55 pp., 15 figs. *eA*).

INSTITUTION OF MECHANICAL ENGINEERS

Journal, April 1915, London

Convertible Combustion Engines, discussion
Graphical Method of Finding Inertia Forces, Wm. J. Duncan (abstracted)
The Chemical and Mechanical Relations of Iron, Cobalt and Carbon, J. O. Arnold and A. A. Read

A Graphical Method of Finding Inertia Forces, William J. Duncan

The paper develops a graphical process for the solution of certain problems in the dynamics of machines. In it the fundamental element is the determination of the point called the acceleration center, and the author shows that this can be ordinarily done when the circle of inflections has been constructed. This latter is a curve representing the locus of points in a body whose respective velocities and accelerations are parallel. It is so named because any point on it is momentarily at a point of inflection on its path. The locus of points, whose respective velocities and accelerations are perpendicular, may be called, according to the author, the circle of zero tangential acceleration. The author shows that a knowledge of the circle of inflections is of very material help in the determination of the acceleration center, and further shows how, having given the circle of inflections from which it can be determined and the direction of the acceleration of one point, the acceleration center can be constructed. In this way, he proves that the accelerations of all points in magnitude and direction can be found when the circle of inflections, the direction of the acceleration of one point and the magnitude of the acceleration of another point are known. He then proceeds to the discussion of the application of his constructions to the dynamics of machines; for example, theory of a link of a four part mechanism; oscillating cylinder mechanism, such as an oscillation engine, accelerating force on the piston and piston rod; determination of the inertia forces in a Gnome engine, etc. Stricter mathematical proofs of the statements and constructions proposed in the body of the paper are given in an appendix (30 pp., 25 figs. *tm*).

TABLE 1 COMPARATIVE EFFICIENCIES OBTAINED IN THE VANDERGRIFT AND DELRAY TESTS

Percent Rating Developed	Vandergrift Tests Slow-Chain Method		Delray Tests	
	Gross Efficiency	Net Efficiency	Gross Efficiency	Net Efficiency
74	79.82	79.4	80.2	77.7
110	77.45	77.1	79.0	76.4
126	76.00	75.7	78.5	75.8
148	75.86	75.6	77.8	75.0

INSTITUTION OF MINING ENGINEERS

Transactions, vol. 49, part 1, March 1915. London

Power Costs, William B. Woodhouse
The Absorption of Oxygen by Coal, Part VII, J. Ivon Graham
The Lateral Friction of Winding Ropes, H. W. G. Halbaum (abstracted)
Winding Engine Signals, Wilfrid H. Davis
The Nature of Explosions, Professor Harold B. Dixon

The Lateral Friction of Winding Ropes, H. W. G. Halbaum

In this article is discussed the question of lateral friction of winding ropes, in particular for the case of the ordinary wide drum. It is claimed to be merely an attempt to state the problem in the simplest terms.

A is the angle of maximum friction. When the rope between the pulley and the drum lies in the same vertical plane as that of the pulley, there is no lateral friction. This line of no friction is called by the author, the "center-line." When the rope has diverged to its utmost limit from the center-line, it makes an angle A with that line, called the *angle of maximum friction*. Under no circumstances need it exceed 3 deg., and in many cases 1 deg. During the wind-

ing, the angle of friction varies from zero to A, but it is the maximum angle only that must be taken into account, since it is invariably the same portions of rope which suffer from its influence in each successive wind.

Several ways have been proposed to reduce the angle A, for example, by reducing the width of the drum so that the rope is obliged to coil upon itself during the latter half of the wind. A may also be kept at its lowest possible value by so attaching the rope to the drum that it lies truly on the center-line when the cage is at "meetings" or half-depth. In some cases there may be a little difficulty in the centering of the rope at the middle point of the winding, but this difficulty might easily be overcome by fitting the winding drum, or at any rate the lower portion of the wind, with a spiral screw-thread, which would guide the rope in the path required to insure its centering itself at the middle point of the wind. This spiral screw-thread is not grooved, however.

The author develops the following formula, for which it is assumed that the normal diameter of the rope is d inches, the width of the drum employed by each coil of rope on the drum is 1.1 d inches, the rope being centered at "meetings":

$$A = \frac{10H}{RL}$$

where H is the height of the banking-level above the onsetting-level, L the length of rope extending from the pulley to the drum and R the ratio of the drum diameter to the normal diameter of the rope (in practice from 110 to 150); H and L may be taken in any units, but both must be in *similar* units. If it be ordered that A shall not exceed a given predetermined numerical value, the winding engine must either be placed at such a distance from the pit that $L = \frac{10H}{AR}$ or the drum must be of such a diameter that $R = \frac{10H}{AL}$, that is to say, if D is the diameter of drum, and d diameter of rope (both in similar units), the following formula must be taken: $D = d \cdot \frac{10H}{AL}$.

The above formula shows that since H cannot be altered for a given mine, A can be reduced only by increasing L or R or both. L may legitimately be extended to 50 yd. (there is an objection to making it too long because many managers prefer the engineman to have a clear view of the banking operations and cages), and then a reasonable value of R will reduce the angle A to about 1.5 deg., even in the case of the deepest British coal mine, always provided that the ropes are so adjusted as to center themselves at "meetings." In the case of shallow mines, the lateral friction should be quite a negligible quantity.

The author, among other things, comes to the following conclusions: Other things being equal, the lateral friction varies as the square of the angle A of friction; other things being equal, the destructive character of the lateral friction varies with the roughness of the rope; hence, ropes of the flattened-strand and locked-coil type suffer less than ropes of the ordinary type, because the coefficient of friction is less. Lubrication reduces lateral friction.

In the discussion which followed numerous objections were made to the statements of the above speaker.

Hugh Bramwell, who lately installed at the Cwm Colliery, Pont-y-pridd, Wales, a hoist to raise 12 tons of coal per wind, from a depth of 800 yd., stated that the maximum permissible lateral angle should be limited to 2 deg. as an outside figure. In a case within his knowledge, where 2 deg. had been exceeded, the lateral wear on the rope (locked-coil) was material. In the Cwm Colliery installation, the rope was allowed to overlap, this being done to reduce the size of the drum. In that case, the choice lay between a 30 ft. diameter drum weighing, with its shaft, some 150 tons, and no overlapping, and a drum little more than half that diameter, weighing much less, but with overlapping. Mr. Bramwell's opinion was that there was less rope wear when there was overlapping with a lateral angle of 1 deg. than with no-overlapping and a lateral angle of 2 deg.

With regard to the same installation, G. W. Westgarth stated that with the flattened-strand rope 3 in. in diameter, the difference between the load at the start and at the finishing point, due to the weight of the rope alone, would be approximately 16 tons, but if a locked-coil rope 3 in. in diameter were adopted, the difference would be approximately 22 tons. He suggested that these weights were in such relationship to the useful load of 12 tons that there could be gained by their adoption, so far as the lateral angle is concerned, not only a negligible advantage, but a serious disadvantage, and the inference was that in laying out winding engines, it was most desirable that the lateral angle should be arranged for the adoption of such a rope that its weight would be in more economic relationship to its useful load.

An important point in connection with the same installation was that of selecting a proper factor of safety. Having regard to the low cage speed of about 30 ft. per second, and after taking into consideration the smooth running and direct control obtained by the use of an electric winder, it has been decided to adopt a safety factor of about 7 in lieu of the customary 9 and 10; a further reason which prompted the taking of this step is that with so large a dead load there would still be a much larger absolute margin of strength than usual, although a smaller relative margin. Thus a dead load of 20 tons and a factor of safety of 9 gave a margin of 160 tons, while with a dead load of 40 tons and a factor of safety of 7, the margin would be 240 tons (30 pp., 4 figs. *et*).

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Transactions, vol. 30, part 7, March 1915, Newcastle-upon-Tyne

Some Tests on a Diesel Engine, W. S. Burns (abstracted)
On the Strength of Welds Made by the Oxy-Acetylene Process, Professor Campion and W. C. Gray (abstracted)
The Influence of Various Temperatures on the Properties of Admiralty Gun Metal, Professor Campion and Professor John G. Longbottom (abstracted)

SOME TESTS ON A DIESEL ENGINE, W. S. BURNS

The paper presents data on some tests of a Diesel engine carried out in the laboratory attached to the Department of Mechanical Engineering in the Royal Technical College, Glasgow. The present paper covers the following subjects; value of blast pressure and variation of jacket water temperature upon the running of a Diesel engine. It also describes some of the measuring apparatus used. Further data obtained from the same tests are reported in the author's paper, "Oil Fuels and Their Application to the Generation of Power," in the *Transactions of the Institute of Engineers and Shipbuilders in Scotland*, Vol. 57.

From the beginning, it was seen that the ordinary indicator diagram would not be suitable for the investigation of changes taking place in the cylinder during combustion. The combustion part of the cycle in a Diesel engine takes place when the piston is moving very slowly, so that with the usual reciprocating indicator diagram, the record of the pressure changes is crowded into a very small space. Consequently rotary indicator cards were used, and the author fully describes the method of taking such diagrams. As shown in Fig. 7A, the spring and stopper were removed from the indicator barrel, and a card consisting of a circular strip of paper, about 33 in. long by $2\frac{1}{2}$ in. broad, was passed over the indicator drum and also over a wooden drum affixed to a small spindle parallel to the indicator drum. The spindle was driven from the crank shaft and was fitted with a clutch for starting and stopping the cards. To record the position of the beginning of the stroke on the cards, an electrical striker was fitted to the indicator and so adjusted as to make a mark just beneath the indicator pencil when the piston was at top dead-center. The striker was adjusted to a known point on the ordinary receiving card, the adjustment being made at the electrical contact at the flywheel as shown in Fig. B.

The load was kept practically constant throughout each series of tests by adding and taking off small weights, according to whether the rope friction decreased or increased. Before starting a series of tests, the engine was run from 2 to 3 hours at the load required for that series, to insure a steady temperature condition throughout. Fig. C shows a rotary diagram taken immediately after the fuel was shut off, giving the compression and expansion of the air in the cylinder under working conditions. Equal increments of length on the atmospheric line of this diagram represent to scale equal increments of crank angles. The cards travel about 7.6 in. in one revolution, or about 25.6 in. per second, so that the paper was travelling under the indicator pencil at high speed relative to piston displacement at top and bottom dead-centers, this permitting the studying of changes of pressure in the engine cylinder at and around those points in great detail.

On one of the diagrams is shown the motion of the fuel valve to a modified scale relative to the indicator diagram. It was obtained by placing an indicator on the fuel valve in such a way that vertical displacements of the indicator pencil were proportional to the movement of the fuel valve spindle, the indicator drum being driven at a constant angular velocity by a cord from a wheel on the countershaft spindle. Elsewhere the two short vertical lines, one near the top of the compression curve and the other some distance down the expansion curve, indicate the opening and closing of the fuel valve of each diagram.

Experiments With Different Blast Pressures: Several series of tests were run at different blast pressures, the load remaining constant throughout each series. The usual increase of consumption with unsuitable blast air-pressure was found. For example, by dropping the blast air-pressure from 700 to 600 lb. per sq. in. at normal load (about 30 b.h.p.) the consumption is increased by about 0.37 lb. per hour. The diagram shown in Fig. M can be considered typical. The expansion line on diagram *A* shows, as at lighter loads, that the oil burns late in the stroke probably because it is not properly pulverized, thus causing increase of exhaust temperature and pressure above normal. Diagram *B* shows that combustion begins almost at the top dead center and the burning is completed considerably earlier in the stroke.

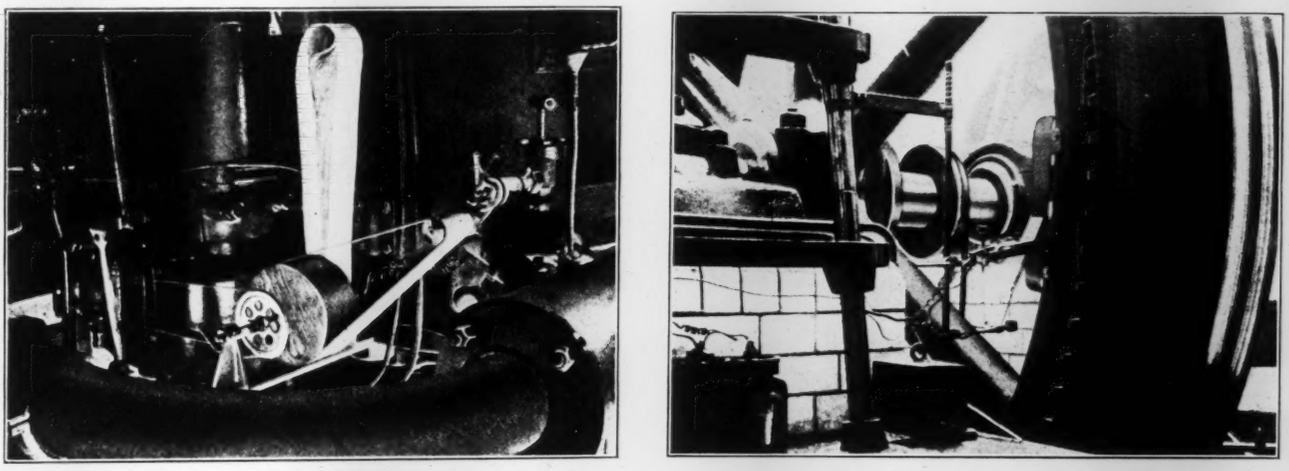


FIG. 7. A AND B ARRANGEMENT FOR TAKING ROTARY INDICATOR DIAGRAMS

In diagrams *C* and *D* the blast pressures caused considerable irregularity about the point of ignition; sometimes combustion starts at the top dead-center, in which case a smooth expansion curve is obtained, or the pressure line followed down the dotted expansion line for some distance, when there is a sudden addition of heat, causing a peak in the expansion line. The late ignition may be due to the cooling action of the blast air. Diagram *E* shows the ignition later than *D*, with a more rapid explosion of the oil, causing a slight knock in the engine cylinder. The diagrams in Fig. N are likewise reproduced here to show how an increase in blast pressure up to the most economical pressure, increases considerably the rate of combustion of the oil. At high blast pressures, ignition is retarded and is attended by a sudden rising pressure, causing peaks on the diagrams. The ragged end of the expansion line of the diagram *C* is caused by the vibration of the indicator spring and mechanism, due to the sudden increase in pressure.

On the whole, it was found that at light loads, the excess air already in the cylinder and the inrush of blast air, with a small quantity of oil, causes late ignition and slow combustion of the fuel. Then as the load increased and the mixture of pulverized fuel and air becomes richer, there is a correspondingly earlier ignition and also an increase in the rate of propagation of the explosion. At all loads, too low a blast pressure pulverizes the oil imperfectly, causing late ignition and incomplete combustion with an increase of exhaust gases at the high temperature, which also indicates that the oil is being handled more economically. The heat given to the cooling water per unit of time at low temperature is about five times as great as the heat given at the high temperature. Tachograph records show that increase in jacket water temperature causes a slight increase of speed, principally due to the cylinder lubricating oil becoming less viscous at the high temperature.

Diagrams *A* and *B*, Fig. O, show that at moderate tem-

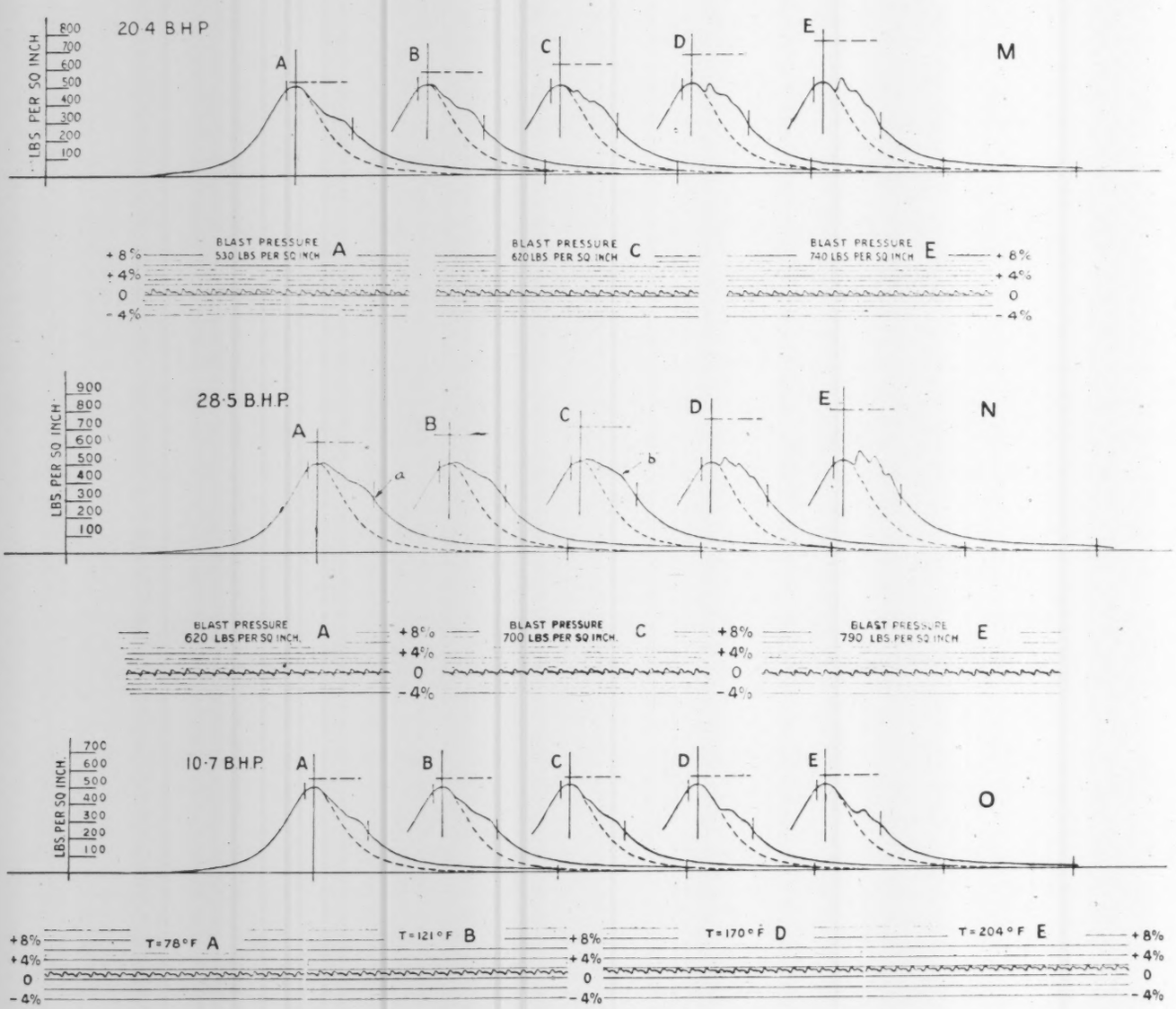


FIG. 7, C, D, E DIESEL ENGINE INDICATOR DIAGRAMS TAKEN WITH DIFFERENT BLAST AIR-PRESSURES

haust pressure and tempearture above normal, while too high a pressure causes late but violent ignition again attended by incomplete combustion of the oil.

Variation of Water Jacket Temperature. Fig. O illustrates the effect of the variation of cylinder water jacket temperature at low load; a similar figure in the original article shows the same at high load. It was found that the higher the temperature of the jacket water, the more economical was the engine. There is a marked decrease in the carbon dioxide and the carbon monoxide present in the exhaust gases at the high temperatures combustion takes place late in the stroke and the rate of combustion is slow, while diagrams *D* and *E* show that as the temperature of the cylinder walls and piston increases, ignition still occurs late in the stroke, but that the rate of combustion is more rapid. As a general conclusion, the author states that at all loads, increase in water jacket temperature does not seem to affect the point of ignition of the oil, but probably causes more rapid and more complete combustion with increased efficiency.

In the discussion which followed, Professor A. L. Mel-

lanby called attention to the effect of varying the blast pressure and to the sensitiveness of the engine in responding to these changes of pressure. In Fig. N the diagrams show what takes place when the engine is working under fairly high loads. Examination of the card *A*, taken when the blast pressure was low, shows that ignition takes place earlier and that the oil burns quietly and comparatively slowly. Card *E*, taken when the blast pressure was high, shows that ignition was late, due probably to local cooling effect and that a comparatively violent explosion took place. James Richardson pointed out that Mr. Burns' work showed that at the lowest powers the conditions of fuel injection were generally a compromise between a quantity of compressed air required to pulverize satisfactorily the fuel and the cooling effect of the expansion of this compressed air as retarding ignition.

On the Strength of Welds Made by the Oxy-Acetylene Process, Professor Campion and W. C. Gray

The paper presents a general discussion on acetylene welding as well as data on the strength of welds by that process. The author starts from the statement made by Dr. C. H. Desch, to the effect that it must be admitted that a joint made by autogenous welding has not the same qualities as the original steel. Tensile tests are not conclusive in showing which part is injured, as the injury to the steel does not always affect the tensile breaking strength, but is revealed when the welded steel is subjected to shock or fatigue.

For the purpose of the present tests, a large number of welds of mild steel were prepared and submitted to static tension and repeated impact tests in the ordinary condition and also after various treatments. The first series of tests were made of round bars of mild steel, $\frac{5}{8}$ inch in diameter, containing approximately 0.25 per cent carbon. No results for contraction of area at fracture have been recorded because it was found that in most cases the fracture was much too raged and uneven to allow of the final diameter being measured. In the results of tensile tests considerable differences were found, not only between the mean results for each treatment but between the individual bars of each set. This appears to indicate that there is an element of uncertainty about a weld, even when it has been made with the greatest care by an expert manipulator. Altogether, it would appear that an average weld might be expected to possess something like four-fifths of the strength of the unwelded steel and that the ductility would be about one-fifth. The maximum strength in tension appeared to vary to no great extent, but the ductility varied considerably from the average.

Hammering increased the ductility and reduced the strength slightly. Reheating after hammering produced a further increase in ductility and at the same time increased the maximum strength. Reheating to the same temperature without previous hammering produced a somewhat larger increase in ductility and a further small increase in strength. In specimens quenched in water and then reheated, the strength has risen to almost that of the unwelded material although elongation has been reduced. From all tests, it appears that under no circumstances does the ductility of the weld approach that of the unwelded portion.

A number of welded bars of the same material were tested under repeated impacts in a Stanton machine. The bars were notched in the center of the welded portion, the diameter at the bottom of the notching being four-tenths of an inch. From these tests it appears that an average weld might be expected to withstand about half as much as similar material unwelded. Hammering has been apparently the most effective treatment so far as increasing the fatigue resisting properties of the material is concerned, but it must be borne in mind that the heating during the welding is extremely local and consequently the metal in the immediate vicinity of the weld is liable to be at a comparatively low temperature and there is danger, when hammering, of vibrating or jarring the portion of the metal that is at black heat, which is productive of brittleness. If hammering is resorted to, the metal should be reheated to a full red heat (800 deg. cent.) in order to remove strains or brittleness which might have been set up during the process.

Reheating or annealing alone appears to be of little value so far as the increasing of fatigue resistance in the welded portion is concerned. This fact, of a portion of the material in close proximity to the weld becoming brittle from being heated to a black heat, explains also the fact observed in the tests; viz., that fracture occurred not in the center of the weld where the notch was, but in close proximity to the weld. Several microphotographs in the original article show the fracture of the original plate and that of the overheated portion after annealing.

A series of repeated impact tests on plates of different thicknesses have shown very clearly that the thicker the plate, the less reliable is the weld and the greater the reduction in strength. Thick material also generally shows less improvement by annealing.

The authors, as the result of a large number of tests and experiments upon autogenous welds, conclude that although there is a wide field of usefulness for oxy-acetylene and similar processes, considerable precaution must be exercised and due regard paid to all the conditions before making use of them, especially where the parts are likely to be subjected to considerable mechanical strain. In any case where failure tends to endanger life and limb, welds, if not entirely prohibited should be accepted with extreme caution.

In the discussion which followed, James T. Milton stated that there had been a great deal of pressure brought to bear upon Lloyds' to accept all kinds of repairs by autogenous welding but, up to the present, no repairs made by this process were accepted in places where if they failed it would mean serious disaster. Lloyds' Register prohibited, and continues to do so, the use of autogenous welding on shell plates, both of ships and of boilers and also on large and important forgings. Neither are crank shafts, repaired by autogenous welding, accepted.

Dr. C. H. Desch pointed out the desirability of distinguishing between the processes of true welding in which the metal was quite continuous in composition and structure throughout, and autogenous welding in which a zone of material fused at a high temperature was produced bordered by two zones of overheated metal. The present experiments confirm the speaker's view that the presence of a zone of overheated metal was very injurious to the dynamic properties, and that subsequent treatment did not restore the original resisting power. It was quite possible for the fused portion to be stronger in every way than the original metal: the weaker part was the intermediate overheated zone (20 pp., 4 figs. *eg*).

THE INFLUENCE OF VARIOUS TEMPERATURES ON THE PROPERTIES OF ADMIRALTY GUN METAL, Professors A. Campion and John G. Longbottom

Investigation of the influence of various temperatures on the properties of admiralty gun metal, annealing of such metal at various temperatures, and of variations in the structure of the metal when heated.

The actual composition of the material used in the research is shown by an analysis, in percentages,—copper, 87.96; tin, 9.77; iron, 0.13; lead, 0.18 and zinc, 1.94.

The tests have shown that from atmospheric temperature to about 200 deg. cent., the material suffers no appreciable change of structure. From 200 to 250 deg. cent., the results are somewhat irregular with a general indication of decreasing strength. From 250 deg. cent. the strength falls continuously until at 750 deg. cent. it is approximately nil, the ultimate elongation appearing at first to increase slightly with rise of temperature, reaching a maximum at about 140 deg. cent. At temperatures higher than this, the elongation rapidly diminishes until at 350 deg. cent. it is less than 1.5. At temperatures below 200 deg. cent. the modulus of elasticity is practically unaffected by change of temperature. Very careful tests were made to determine the constants in Unwin's equation, showing the percentage of elongation.

The results of the authors' tests compared very closely with those of Bach, as well as with those of Unwin, the latter being of particular interest because Unwin's bars were cast at different times and his tests were quite few in number. On the other hand, a marked disagreement occurred between the results of the authors, Unwin and Bach on one side and those of Dewrance on the other.

As regards the influence of annealing at different temperatures, the authors found that annealing at 250 deg. cent. produces quite as satisfactory results as annealing at 700 deg. cent., which latter has sometimes been recommended. On the other hand, however, at 700 deg. cent. the material is devoid of both strength and ductility and extreme care is necessary in the handling of the castings of large size or intricate form. Moreover, the temperature of 700 deg. cent. is dangerously near the temperature at which burning of the material would take place and a small sudden rise of temperature might severely injure, if not completely destroy the casting. Further, at a temperature of 250 deg. cent., the effects of oxidation are comparatively small. It would appear therefore that annealing at 250 deg. cent., apart from cost, offers great practical advantages as compared with that done at the higher temperature.

A careful examination of the structures of the material at various temperatures was made. A study of the equilibrium diagram of the copper-tin series of alloys indicates that little or no change should be produced by heating the material to temperatures below 450 deg. cent., followed by a moderately rapid cooling, except a growth of crystals and possibly some diffusion and redistribution of δ constituents. The specimens heated to temperatures below 200 deg. cent. showed that such was the case, but at 250 deg. cent. a somewhat remarkable and unexpected change in the structure was found to have taken place, the δ compound having apparently been almost completely absorbed by the primary and secondary α resulting in a nearly homogeneous structure typical of a solid solution. It is of interest that no provision for such a change is made in the equilibrium diagram as at present constructed from the works of Shepherd, and of Heycock and Neville, and the authors declare themselves unable to offer an explanation of this remarkable change.

It was found further that sudden changes in mechanical properties occur at temperatures at which, up to the present, no critical points have been recognized in the thermal curves of alloys containing over 80 per cent of copper. With the exception of the remarkable change at 225 deg. to 250 deg. cent., the microstructure of the material shows no changes sufficient to account for the alteration of mechanical properties at various temperatures and it must consequently be inferred that they have no relation to the phase changes in the alloy. In the original article a number of fractures are reproduced in actual colors, which shows clearly the remarkable manner in which the crystals grow with increase of temperatures. An examination of the series of micrographs showed that in all cases fracture appears to take place through the portion richer in tin, which filled the space between the primary α.

The authors believe generally that the crystals are bound together by some form of cementing material, which, upon heating, loses its adhesive propetries and consequently when stress is applied, the crystals composing the mass are parted from each other.

The authors point out further that the temperature of 250 deg. cent. corresponds to the point on the curves where the strength and ductility falls rapidly off and also that it is just at the outside of the zone of irregularity previously referred to. Likewise, this happens to be the annealing temperature at which the maximum strength and ductility are obtained, while at 260 deg. cent., the thin continuous bands of $\alpha + \delta$ complexly reappear. The authors consider that the result of their investigations furnishes strong evidence in support of the existence of some form of cement between the crystalline boundaries upon which the strength and other properties are largely dependent. The authors believe that the "amorphous material" of Beilby is identical with the "cement" of Rosenhaim and Ewen, although no direct experimental evidence to prove it is as yet available.

The authors have noticed, however, during the course of the present investigation, certain phenomena which appear to furnish strong evidence in support of this view. It is a known fact that in these metals at some temperatures marked slips occur after the yield point is passed, but after a short time the material stiffens and carries a further load. In some cases as many as ten such slips have been observed between the yield point and the maximum stress of the material. These slips are invariably accompanied by an evolution of heat. In the opinion of the authors this is due to the amorphous cement crystallizing to such an extent that the adhesion between the crystals of the metals is reduced sufficiently to allow some of the crystals to part from their neighbors under the particular stress. Actual fracture is prevented, however, by the crystal faces rubbing one against the other with considerable pressure, thus reforming a quantity of the amorphous material, with the result that adhesion is again restored. This material is in turn recrystallized under the influence of heat and another slip takes place.

In the progress of tests in the present investigation it has been noticed on several occasions that the temperature suddenly rose several degrees, which in the earlier experiments was attributed to changes of voltage in the heating current. Very close observations during the later tests on the gun

metal resulted in the interesting discovery that, immediately after each of the slips mentioned above, an appreciable increase of temperature in the material took place. This observation appears to be new.

The author considers that the amorphous cement loses its ductility at a lower temperature than that at which it loses its strength, and consequently the ductility of the material deteriorates more rapidly than the strength with increasing temperature.

A brief bibliography is appended (36 pp., 38 figs. *e*).

WESTERN SOCIETY OF ENGINEERS

Journal, vol. 20, no. 4, April 1915, Chicago

Operating Results of the Electrification of Steam Railways, George Gibbs, Edwin B. Katte, W. S. Murray and C. A. Goodnow (abstracted)

Founding of the Western Society of Engineers, Walter Katte

Wind Stresses in the Frames of Office Buildings, Albert Smith, W. M. Wilson (abstracted)

OPERATING RESULTS OF THE ELECTRIFICATION OF STEAM RAILWAYS, George Gibbs, Edwin B. Katte, W. S. Murray and C. A. Goodnow

The data presented by the speaker showed that as compared with steam operation, the first cost of electrification is not in its favor. For example, a modern steam locomotive costs about $25,000 and an electric locomotive of the same capacity, $40,000. The cost of power station, transmission lines, sub-stations and working conductors must be added to that, which will bring the equivalent cost up to $110,000; hence, there should be a large saving in operating cost to cover the increased fixed charges, or another good reason for incurring the additional expense. The New York Central electrified its lines into Grand Central Terminal because it has a bad four-track tunnel condition to deal with at the most congested point of traffic, but when electrification was decided upon, it resulted in very radical changes in the movement and operation of the trains. This latter fact makes direct comparison between the former steam and the present electric operation impossible and only a general comparison can be made. The average cost per locomotive mile from a large number of records has been found to be, on steam roads, about $0.26 including fuel, supplies, maintenance, repairs and enginehouse expenses. A similar figure for electric locomotives in and about New York City can be found to be about $0.21. If, however, fixed charges are added, the comparison becomes $0.30 for steam locomotives and about $0.60 per mile for electric locomotives, this, however, without taking into consideration the fact that conditions in the New York case permit an average of 85 miles per day for electric locomotives while the steam locomotives are averaging about 150 miles per day.

As a measure of the reliability of electric equipment comparison of the locomotive or car miles per detention is used. During the year 1914 the average locomotive miles per detention was 23,000 while the multiple unit cars averaged 51,000 miles per detention. The train minute delays due to electric power troubles totaled 840 minutes for the year, out of which 535 train minutes were due to aerial lines, 244 minutes delay to the third rail, 25 minutes to sub-stations and not a single minute's delay during the eight years of operation, to power stations. The electric locomotives used by the New York Central in express passenger service have a speed of 60 miles per hour when drawing a 1,200 ton train. The locomotive is equipped with an oil-fired flash type boiler having a capacity of 2,000 lb. of water per hour for heating through trains. The complete weight of the locomotive is 132 tons, all of which is carried in the drivers, thus giving a draw-bar pull of 66,000 lb. assuming 25 per cent adhesion.

WIND STRESSES IN THE STEEL FRAMES OF OFFICE BUILDINGS, Professor Albert Smith

The paper presents methods of computation of two, three and four bay buildings, the calculation being carried for the case of two bay buildings to the ninth story, and for three bay to the fourteenth. The author uses the method of least work, and asserts that no reliance should be placed, for safe distribution of stresses, upon the passing of the elastic limit by some fibers of an office building. The paper is of great interest, but because of its mathematical nature entirely unsuitable for abstracting. The author believes that the results given in the paper are not usable in the first and second stories, but that for buildings whose bays are equal these results will give very reliable indications of the stresses above the second floor.

WIND STRESSES IN THE STEEL FRAMES OF OFFICE BUILDINGS, Professor Wilson

The paper, presented jointly with the above paper by Professor Smith, begins by establishing certain assumptions upon which the analysis is based. From these, and certain fundamental equations, the author determines the stresses in the frame. He shows that it is possible to write as many equations for each story as there are columns in the story, plus one. As the only unknown quantities in these equations are the changes in slopes at the extremities of these columns, and the deflection in a story common to all columns, there are as many equations per story as there are unknowns. By solving these equations the slopes and deflections can be determined, and this permits one to determine the moments, which in their turn make it possible to determine the shears. With the shears in the girders known, the direct stress in any column can be determined by taking the column as a free body and equating the sum of the vertical forces equal to zero.

The paper gives further a detailed comparison of the "approximate method" with the slope-deflection method of computation, the "approximate method" being described in full. As regards the slope-deflection method, the author states that it contains not approximations, except those contained in the original assumptions, and it can be shown that the inaccuracies in the assumptions do not affect materially the results; therefore, the stresses in a frame as given by the slope-deflection method will be very accurate. The greatest value of the method is said to be not for purposes of actual calculation of buildings, but as a standard by means of which the accuracy of the approximate methods may be determined.

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

MEETINGS

NEW HAVEN, APRIL 21

The regular spring meeting of the New Haven Section was held in New Haven on April 21. The general subject of the meeting was The Development of Machine Tools, and six papers were presented on different aspects of the subject as follows: The Early History of Machine Tools, by Prof. Joseph W. Roe, Sheffield Scientific School, Yale University; Modern Developments in Milling Machines, by Luther D. Burlingame, Brown and Sharpe Manufacturing Company, Providence, R. I.; Milling Cutters and Cutting Tools, by A. L. DeLeeuw, Singer Manufacturing Company, Elizabethport, N. J.; Modern Development in Vertical Boring and Turning Machines, by E. P. Bullard, Jr., The Bullard Machine Tool Company, Bridgeport, Conn.; Special Forms of Presses for Working Sheet Metal, by Darragh deLancey, Waterbury, Conn., and Grinding as a Manufacturing Process, by H. W. Dunbar, Norton Grinding Company, Worcester, Mass.

The meeting was divided into two sessions, one in the afternoon and one in the evening. A portion of each session was given up to discussion of the papers presented at that session. The registration was 125, of whom 69 were from places outside of New Haven.

CINCINNATI, APRIL 22

At a joint meeting of the Cincinnati Section and the Engineers' Club of Cincinnati, held on April 22, W. C. Devereaux spoke on Forecasting the Weather. The address was illustrated by lantern slides, and by such of the instruments of the Weather Bureau as may be easily transported, including the sunshine recorder, wet and dry bulb thermometer for indicating the humidity, and recorders for wind velocity and direction. The speaker outlined the methods used in obtaining the temperature, velocity and direction of the currents of air in various strata above the surface of the earth, and showed the development of a storm and its progress across the surface of the country by successive weather maps, and gave reasons for the storm's progress. The weather maps for the days of unprecedented rainfall in March and April, 1913, when the great floods occurred in the Miami Valley, were shown and discussed. The speaker concluded his remarks by a discussion of the methods used in predicting the weather in Cincinnati. About 75 members and guests were present.

MINNESOTA, APRIL 22

A meeting of the Minnesota Section of the Society was held on April 22, at which D. W. Flowers, of the St. Paul Gas Light Company, gave a paper on The Manufacture of Illuminating Gas. Mr. Flowers confined his remarks to the manufacture of coal gas, carburetted water-gas and oil gas. He outlined in an elementary manner the principal features of the generation of gas by these three processes, and referred to the characteristics of the materials used in gas manufacture, such as coke, tar and ammonia liquor. He discussed the advantages of the various systems, pointing out the economic considerations which, in the vicinity of St. Paul, lead to the manufacture of all-water gas. He concluded with illustrations descriptive of oil gas apparatus, coal gas apparatus and water gas apparatus.

BOSTON, APRIL 23

A joint meeting, under the charge of the A.I.E.E., was held on April 23, at which Frank W. Hodgdon, chief engineer for the directors of the Port of Boston, presented a very interesting paper on the Electrical Equipment used in the Commonwealth Pier Development for the Port of Boston. Mr. Hodgdon did not confine his remarks to the electrical equipment, but gave many details of dock and building construction, presented a large number of lantern slides, and treated the entire subject in a very comprehensive way, which led to considerable discussion at the close of his talk.

BUFFALO, APRIL 27

A meeting of the Buffalo Engineering Society was held on April 27, at which Charles W. Parker presented a paper on Patents. Mr. Parker went into a thorough discussion of the patent laws of this country, with a full description of the various kinds of patents which can be obtained and a complete description of the methods which are followed by patent attorneys and by the patent office in Washington.

Another paper was presented by H. V. Alverson on Conservation, referring to the conservation of Niagara Falls Power. Mr. Alverson's paper dealt with the development of the power plant at Niagara Falls, with complete statistics of the power being generated and the power available, due to the flow of water in Niagara River. He also gave complete information regarding the distribution of the power in Buffalo and the surrounding cities, both in this country and in Canada. After the reading of the paper, a spirited discussion ensued, led by F. A. Lidbury of Niagara Falls, and a resolution was presented empowering the president to appoint a committee for the purpose of investigating the power situation and presenting a report to the society for their action in connection with a meeting of the Central Council of Business Men's Association, which is arranging a conference of manufacturers, Boards of Trade and Business Association of Western New York Municipalities to effect a permanent organization for a persistent movement to obtain low prices for Niagara Falls power at as early a date as possible.

At this meeting, the following officers for the ensuing season were elected: John Younger, president; W. A. James, 1st vice-president; J. G. Melendy, 2nd vice-president; W. J. Gamble, secretary; W. M. Dollar, treasurer, and David Howard and David Bell as directors for two years.

The final meeting of the season was held on May 6. This meeting was addressed by Prof. R. C. Carpenter, of Cornell University, on Concrete and Machinery for Making Cement. Professor Carpenter presented some very interesting details on the subject, and, during the discussion which followed, he gave additional interesting information. This meeting closed the season of the Buffalo Engineering Society, which now has a membership of about 325. During the season, fourteen meetings were held and the average attendance was about 150 to 175.

NEW YORK, MAY 11

A meeting of unusual interest was held on May 11 by the New York local section on the newly developed process of metal spraying. The paper of the evening, entitled Metal Spray Processes in Engineering and Art, was presented by John Calder, member of the society, who traced the de-

velopment of the school process from the early beginning in Europe down to the improved American processes, and discussed not only the interesting theoretical considerations involved, but also the features of practical interest in the use of the process. He showed the details of the spraying instrument by slides, and pointed out the limitations of the process in certain directions. Interesting data was also given relative to the cost of spraying the various metals, and as to the costs of the blau-gas, oxygen and compressed air used. The lecture was followed by a practical demonstration of the process in the basement of the Engineering Societies Building, at which a commercial spraying instrument was shown in operation, coating various objects of metal, wood, stone, cloth and paper with brass, copper, zinc and aluminum. A more complete account of the meeting will appear in an early issue of The Journal.

NECROLOGY

JAMES McBRIDE

James McBride, a member of the Society since 1886, was born on April 27, 1836. When he was a very young man, he learned the trade of pattern maker. From 1858 to 1865, he was employed by the Dusquesne Engine Works at Pittsburgh at pattern making and the erection of machinery on steam boats. During this period he assisted in the erection of the machinery on thirty-seven boats. It was at this time that he obtained a Government license for engineer of the 2nd Class on the western rivers.

In the four years that followed, he established a pattern shop of his own in Pittsburgh in which he made patterns, mechanical drawings and designed machinery. He gave this up, however, to take a position as draftsman for the Root Steam Engine Company of New York, but later returned to the Dusquesne Engine Works as draftsman and designer. In 1876, he entered the employ of the New York Dye Wood Extract and Chemical Company of Brooklyn as chief engineer. Three years later, he became superintendent of the Stamford Manufacturing Company in Stamford, Conn. Mr. McBride died at his home in Stamford, Conn., on April 13.

WILBER H. TRAVER

Wilber H. Traver was born at Mattawan, Michigan, on May 3, 1863. He had a common school education, but as the mechanical profession and especially railroad work appealed to him very strongly, he served an apprenticeship with the Michigan Central Railroad as a machinist from 1880 to 1883. In 1889, he became master mechanic for the Atchison, Topeka and Santa Fe Railroad and, following this, he held the same position with the Kansas City, Pittsburg and Gulf Railroad. In 1895, he took a position with the Rand Drill Company in the sales department and later became manager of the Chicago office of this company.

In 1906, Mr. Traver took a position with the Pneumatic Tool Company as manager of the mining department, where he remained until his death, which occurred at Houghton, Michigan, on April 15.

JOHN M. SHERRERD

John M. Sherrerd was born at Scranton, Pa., on February 26, 1859. He graduated from Lafayette College in 1878 with high honors and, during the two following years, he took a course at the Columbia School of Mines.

After the completion of this course at Columbia, Mr. Sherrerd became chemist for Mr. Ario Pardee at Secaucus, N. J., for two years and then became connected with the Troy Steel and Iron Company where he remained thirteen years until the company went into the hands of a receiver. He was engaged in a number of capacities with this latter company, first as chief chemist, then metallurgist, and later ran the blast furnace.

In 1895, Mr. Sherrerd became connected with the Taylor Iron and Steel Company as General Sales Agent. At the time of his decease, he held the position of Assistant to the President of the Kennedy Stroh Corporation of Pittsburgh, Pa.

Mr. Sherrerd was a member of the following societies: The American Society of Civil Engineers, The American Institute of Mining Engineers, The American Society of Testing Materials, the Lake Superior Mining Institute, The National Geographical Society and the Engineers Club of New York. He died at his home in Easton, Pa., on April 16.

EDGAR H. MUMFORD

Edgar H. Mumford was born at Groton, Mass., on Sept. 20, 1862. He was graduated from Massachusetts Institute of Technology in 1886 in the Department of Mechanical Engineering.

In 1886, he entered the service of the Union Pacific Railroad at Omaha, Nebraska, in the motive power department and left there after promotion to the position of master mechanic of the Leavenworth Division, to become superintendent of Russell Wheel & Foundry Company, Detroit, in 1889. After three years in this position, he came east and became associated with Henry R. Worthington, Inc., Brooklyn, N. Y. Shortly afterward he was placed in charge of the new foundry built by this company at Elizabeth, N. J. Mr. Mumford left this position to become manager of the New York office of Bement, Miles & Company of Philadelphia, which he opened for them at that time. He remained in this position until the summer of 1895, when he started in business for himself. With Harris Tabor and Angus Sinclair, he purchased the business of the Tabor Manufacturing Company from Manning, Maxwell and Moore and remained with it as secretary and treasurer for ten years. In 1900, the Company's plant was moved to Philadelphia, and in 1905 he resigned from it to form the E. H. Mumford Company, builders of molding machines, of which he was president and treasurer. In 1909, he became vice-president and general manager of the Mumford Molding Machine Company, where he remained until shortly before his death, at which time he was arranging to enter the molding machine business under his own name.

Mr. Mumford was for twenty years an inventor and builder of molding machines known as "Mumford Machines," and was a recognized authority on them and an expert in their application to the foundry.

He was a member of the Engineers Club, the Machinery Club, Technology Club, and the Art Club of Philadelphia. He died at his home in Plainfield, N. J., on April 18.

GEORGE T. REISS

George T. Reiss was born in Cincinnati, Ohio, on December 6, 1849. He was educated in the common schools, supplemented by private instruction in drawing, designing and mechanical philosophy. In 1877, he became draftsman at

the old Cope and Maxwell shops in Cincinnati, but in 1878 he was placed in charge as a master machinist of the engineering department of the Niles Tool Works, which was moved from Cincinnati to Hamilton, Ohio, in 1871. He was chief mechanical engineer of the concern, later becoming superintendent of the drafting department and subsequently elected to the board of directors, of which he was also secretary. Later he became vice-president of the directorate, which position he held until the time of his death. Mr. Reiss died at his home in Hamilton on May 5.

FRED STARK PEARSON

Fred Stark Pearson, who lost his life on May 7 in the Lusitania disaster, was born July 3, 1861, in Lowell, Mass. He graduated from Tufts College in 1885 with the degree E.E. and received the degree of M.E. in 1886.

In the early part of his career, after leaving college, he held the positions of chemist for the Boston Butter Company, superintendent of the Blue Ridge Gold Mining Company in Virginia, mining expert surveying copper mines in Texas and gold deposits in Brazil, manager of the Somerville Electric Light Company, consulting engineer for the Woburn Electric Light Company, and for Chandler Electric Light Company in Halifax, consulting engineer for the American Aluminum Company and chief engineer in the steam and electric departments of the West End Street Railway Company in Boston.

His later enterprises, the result of his organization, may be classed as electric light and power companies, electric tramway companies, telephone companies, gas companies, steam railroads, irrigation and land companies, lumber manufacturing companies and mining and chemical companies. These companies were centered principally around the following cities: Mexico City, Mexico; Rio de Janeiro and Sao Paulo, Brazil; Barcelona, Spain; Toronto, Winnipeg and Niagara Falls, Canada; and El Paso and Juarez in Texas and Northwestern Mexico.

In steam railroads, the principal ones in which he was interested are the Mexico and Northwestern Railroad from Chihuahua to El Paso in the center of several million acres of timber and mining land which his companies own, and the Denver & Salt Lake Railroad, or Moffatt System, extending now from Denver to Steamboat Springs, but to be pushed through to Salt Lake City in the near future. The details of his numerous projects, however, were handled by his New York staff, a corporation called the Pearson Engineering Corporation, Ltd., in conjunction with the local staffs in each of the cities where his public utilities were located.

Dr. Pearson was a member of a large number of technical societies, among which were the following: American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Society of Naval Engineers, the Institute of Electrical Engineers (England); the American Institute of Mining Engineers, the American Electro Chemical Society, the New York Railroad Club and the American Forestry Association.

JOHN BIRKINBINE

John Birkinbine, whose death occurred in Cynwyd, Pa., on May 14, was born in Reading, Pa., on Nov. 16, 1844. His education was received at public schools and the Friends High School in Philadelphia, the Hill School at Pottstown, Pa., and the Polytechnic College of Pennsylvania. His studies were interrupted by military service in 1863-4 on scout duty with the Union Army under two enlistments. Later, two years were devoted to practical work in a machine shop and subsequently he was associated with the late P. L. Weimer as the firm of Weimer and Birkinbine, which operated the Weimer Machine Works at Lebanon, Pa.

Much of his work has been in mining, metallurgy and blast furnace construction. As manager for the South Mountain Mining & Iron Company, he carried on experiments with various fuels for iron ore smelting while maintaining the furnace in constant operation. The carefully recorded results obtained were widely published and are referred to in text books by other metallurgists as being the most complete made.

From his Philadelphia office, he has been sent to nearly every state and to Canada and Mexico for examinations, reports, constructions of or improvements to iron ore mines, blast furnaces, iron works, water supplies, hydraulic developments, irrigation projects, etc., and his engineering knowledge has been requisitioned by several European corporations. A number of business trips were made to Mexico beginning with a visit to the Cerro de Mercado at Durango, Mexico, before railroads were established in that part of Mexico.

Mr. Birkinbine was probably the pioneer to suggest an iron industry at the head of the Great Lakes using coke made from Pennsylvania coal and his report was an important factor in establishing the iron industry at the head of Lake Superior; the blast furnace at West Duluth, Minn., was built under his supervision. He was engaged by the State of Texas to investigate the practicability of iron manufacture in the Lone Star State. As an engineer, he cooperated with Mr. E. S. Cook of Pottstown, Pa., who did much to advance the iron industry. He was for some years consulting engineer for the Philadelphia and Reading Coal and Iron Company, and held a similar position with Mr. Thomas A. Edison during the latter's early experiments on magnetic concentration of iron ore, and with Witherbee, Sherman and Company in beneficiation tests; also for the Colorado Fuel and Iron Company for the enlargement and improvement of their works and the construction of an augmented water supply system.

He has also acted as an expert for financial interests and for a number of the greatest corporations and several large railroads in this country. He was chief engineer, vice-president and chairman of the Committee of Awards of the National Export Exposition, served on Juries of Awards at the Centennial, World's Columbian, Pan American and Cotton States General Expositions, and was named for similar duties for others.

Since its inception in 1905, he has been chairman of the Water Supply Commission of Pennsylvania, and was active in forming the Pennsylvania Forestry Association. He was also active in the formation of and served as secretary to the United States Association of Charcoal Iron Workers and for nine years edited their journal. For many years, he was special agent for the United States Geological Survey, preparing the reports on iron ores for the 11th and 12th censuses and that on manganese ores for the 12th census. He was appointed by the Secretary of the Interior as expert metallurgical engineer for the Bureau of Mines.

During his career, Mr. Birkinbine has also maintained his

specialty in hydraulic engineering, acting as engineer on water supplies for various municipalities. He has not only witnessed, but has had active participation in the development of water power for electrical energy. While he was at college, electricity was a laboratory experiment only, and the use of water power was then confined to limited volumes at low heads for direct mechanical purposes; his activities have covered the development of hydro-electric science to its present advanced stage. In 1888, he prepared a comprehensive report on the development of the great water power of the St. Louis River in Minnesota, considering a fifteen mile transmission, though no water wheel manufacturers would guarantee turbines for heads above 35 feet.

For ten years, he served as president of the Franklin Institute in Philadelphia. He was also a member of the Engineers Club of New York, The American Society for Testing Materials, the Engineers Club of Philadelphia, of which he was president in 1893, the Manufacturers Club of Philadelphia, the Pennsylvania Foundrymen's Association, the George C. Meade Post 1, G. A. R. of Philadelphia, an honorary member of the Canadian Mining Institute and a member of the Institute of Mining Engineers, of which he has been manager, vice-president and president.

PERSONALS

Carl Stenbol has accepted a position with the Anaconda Copper Mining Company, Anaconda, Mont., as mechanical engineer and designer.

Willis W. Jourdin, until recently chief engineer of the power division of the Chino Copper Company, Hurley, New Mexico, has been placed in charge of the power plant jointly owned by the Inspiration Consolidated Copper Company and The International Smelting Company at Miami, Arizona.

M. R. Hull who, for the past six years has been connected with the engineering department of the Anaconda Copper Mining Company, at Great Falls and Anaconda, Mont., has been appointed superintendent of construction at the Washoe Smelter at Anaconda.

J. Norman Bulkley, late consulting mechanical and electrical engineer to the General Mining and Finance Corporation, Ltd., London and Johannesburg, has opened a joint office with S. C. Thomson, in New York, for the practice of consulting engineering.

Horace R. Wentzell has severed his connection as superintendent of the Bourke Machine Company of Detroit, Mich., and has become affiliated in a similar capacity with the Houk Manufacturing Company of Buffalo, N. Y.

David Moffat Myers announces that he has consolidated his practice with that of John S. Griggs, Jr., an electrical engineer with offices at 110 West 40th St., New York. Mr. Myers was formerly mechanical engineer for the United States Leather Company but since 1906, he has had an office of his own at 17 Battery Place. He has specialized on the efficient operation and design of industrial plants with special reference to steam and fuel economy and to the use of exhaust steam in the production of high over-all efficiency.

Thomas A. Edison received the Civic Forum Medal of Honor for Distinguished Public Service on May 6, 1915. President Butler of Columbia University presided. The speakers of the evening were Com. G. Marconi, Charles P. Steinmetz, Richard C. Maclaurin, Charles A. Coffin and Percy Mackaye.

The following members of the Society were speakers at the annual banquet of the students of Sibley College of Engineering of Cornell University held on April 23: Calvin W. Rice, Secretary of the Society, Thomas E. Durban of the Erie City Iron Works and Prof. D. S. Kimball of Cornell University.

On May 20, Mr. Harrington Emerson, one of the foremost efficiency engineers in the United States, addressed the Milwaukee Efficiency Society on The Natural Law of Organization.

STUDENT BRANCHES

Members of student branches are requested to notify the Secretary of any change in address as promptly as possible, in order to facilitate delivery of The Journal.

BROOKLYN POLYTECHNIC INSTITUTE

A regular meeting of the Brooklyn Polytechnic Institute Student Branch was held on April 17. Reports of the inspection trip, lasting ten days, which was held during the spring vacation, were given by W. A. Betts and H. A. Brandt. The trip included the cities of Cleveland, Detroit, Chicago, Cincinnati, Pittsburgh and Washington. The manufacturing plants visited were the Brown Hoisting Machinery Company and the new Pennsylvania ore docks in Cleveland, the Ford and Packard automobile plants in Detroit, the plants of the Illinois Steel Company, the By-Products Coke Company and the Pullman Palace Car Company in Chicago, the factory of the Proctor and Gamble Company in Cincinnati and the plants of the Westinghouse Machine Company, the Westinghouse Electric and Manufacturing Company and the American Bridge Company at Pittsburgh. The University of Cincinnati was also visited.

A meeting of this branch, which took the form of a convention, was held on May 1. The meeting of the afternoon was preceded by an inspection trip to Peter Doelger's Brewery in New York. At the afternoon session, Prof. W. D. Ennis spoke on The Progress of the Polytechnic Institute Student Section. He spoke of the practice which the members received in self-government by the participation in and conduction of the technical meetings. The scope and increased number of inspection trips and the large membership of the section were also mentioned. Herman Brandt, '16, gave an illustrated talk on The Una-Flow Engine, showing the history and development of this type of prime mover to date, and Prof. H. P. Hammond presented a paper on The Selection of Hydraulic Turbines, dwelling on the modern types of machines. He also gave a brief history of water wheels, and gave a short sketch of the men who were prominent in developing this type of prime mover.

In the evening, the annual dinner of the section was held in New York. The speakers were President F. W. Atkinson, Consulting Prof. George A. Orrok, Dr. M. C. Ihlseng and Dr. J. B. Chittenden.

At this meeting, the following officers were elected: Herman Brandt, chairman; George L. Kay, vice-chairman; Charles E. Rohmann, secretary; Joseph L. Kopf, treasurer.

COLORADO AGRICULTURAL COLLEGE

At a meeting of the Colorado Agricultural College on March 10, D. R. Stephens gave an interesting talk on the tempering of high speed steels. The talk included details of the change in the structure and hardness, as well as temperature necessary. Methods of annealing tool steels were also touched upon.

S. L. Conrey gave a talk on the eight-cylinder Cadillac. After giving a short history of the development of eight-cylinder gas engines, he went into the details and advantages of the Cadillac automobile as equipped with the eight-cylinder power unit.

At a meeting of the branch on March 24, T. H. Sackett gave a talk on The Works of the Colorado Fuel and Iron Company in Pueblo. In the plant, the entire process of reducing the crude ore to iron and its subsequent transformation into rails, bolts, rods, nails, wire and other iron and steel products may be followed. Every effort is made there

to utilize all the gas from the blast furnaces, which is also used to produce steam for the power used on the grounds. Practically all the power used by the steel mills is generated in this way. This company has also a very complete machine shop and foundry, and makes a great portion of the machinery used by the mining industries of the state.

At the meeting held on April 30, Mr. Searles gave an interesting treatise on Mechanical Stokers. He followed the development of the mechanical stoker from the crude, early attempts of the inventor to the more or less successful types in use today. He concluded by mentioning the various means used to bank the fires when automatic stokers are used. E. Murray gave a very detailed description of the plant of the Denver Rock Drill Company, and emphasized the fact that this is one of the most progressive manufacturing plants in the west. It is equipped with very complete laboratories for testing the steel put into their sole product, the rock drill. As they produce but the one article they have been able to equip themselves in a very thorough manner. The shops are well managed and the workmen well protected. The machine shop is fitted with the most modern lathes, grinding machines, drill presses, etc. Besides making the ordinary post and jack-drills they are now putting out an electric drill.

CORNELL UNIVERSITY

A meeting of the Cornell University Student Branch was held on April 21. I. N. Knapp gave an illustrated talk on The Origin, Occurrence and Production of Petroleum and Natural Gas. He gave a general survey of the whole field of gas and oil production, touching on such phases of the subject as the different sorts of oil "sands," theories of the occurrence and origin of oil and gas methods of well-drilling and the control and extinguishing of oil and gas fires.

KANSAS STATE AGRICULTURAL COLLEGE

At a meeting of the Kansas State Agricultural College on April 14, P. J. Freeman, a member of the engineering faculty and formerly mechanical engineer with the Gullett Gin Company of Arnite, Louisiana, addressed the student branch on The Mechanical Engineer in the Cotton Industry. The speaker discussed how this problem has been solved during the past century and outlined other problems which await the genius of the engineer. The speaker illustrated the problem which confronted the early growers by passing a sample of seed cotton among the members of the society and requesting them to separate the seed from the cotton fibre. The manufacture and operation of gin linter sand compresses were discussed and illustrated by means of sketches and lithographs.

C. A. Carter, a student member, gave a paper on Irrigation in Western Kansas. Mr. Carter gave a very interesting discussion on the problems of the irrigation in the western part of the state, particularly in the Arkansas Valley.

LEHIGH UNIVERSITY

At a meeting of the Lehigh University Branch on April 9, L. Mardaga spoke on Diesel Oil Engines and R. C. H. Heck on Speed-Reducing Gear Chains.

On May 13, the following officers were elected: C. H. Shuttler, president; W. C. Hartman, secretary; C. H. Thomas, treasurer, and G. B. Adams, librarian.

Professor Butterfield spoke on Municipal Engineering.

LELAND STANFORD UNIVERSITY

At the regular meeting of the Leland Stanford University held on April 27, the following officers were elected for the first semester, 1915-1916: W. H. Warren, chairman; H. F. Elliot, vice-chairman, and F. G. Hampton, secretary-treasurer. Dr. Durand was recommended to the President of The Am.Soc.M.E. for the office of honorary chairman.

Mr. Stebbins of the Engineering Faculty gave an interesting talk on his experience in Locomotive Testing.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The annual banquet of the Massachusetts Institute of Technology Student Branch was held on April 29. The attendance at the dinner was the largest in the history of the Society, 102 being present as against 65 the year before. At this meeting the following officers were elected for the ensuing year: K. C. Richmond, chairman; P. Y. Loo, vice-chairman; C. E. Shedd, secretary; J. W. Stafford, treasurer, and G. W. Tuttle, R. M. Snyder and E. W. Rounds to comprise the governing board.

The speakers of the evening were Howard Elliott, president of the New York, New Haven and Hartford Railroad; Albert B. Tenney of the C. H. Tenney Electric Company, Prof. H. W. Hayward and Prof. E. F. Miller.

PENNSYLVANIA STATE COLLEGE

A joint meeting of the engineering societies at the initiative of the A.S.M.E. Section of the Pennsylvania Student Branch was held on April 16. The purpose was to insure a closer relationship among the engineering students. President Garman of the mechanical engineering section presided at the meeting. Prof. E. D. Walker, dean of the engineering school, and Prof. J. A. Moyer of the A.S.M.E., spoke on Engineering and the Fellowship of Pennsylvania State College Engineers.

At a meeting of the Branch on April 30, C. F. Kennedy spoke On Mines and Mine Problems. He spoke of the general features of the mine and described in detail the collieries, breakers, hoisting engines, boiler plants and various electrical apparatus. The problems of efficiency and repairing were then discussed and intensified by the speaker's practical experience.

PURDUE UNIVERSITY

A meeting of Purdue University Student Branch was held on April 27. Jack Abbott, superintendent of the Lafayette City Street Railways of the Fort Wayne Northern Indiana Traction Company, spoke on The History and Comparisons of the Power Units in Use in the Lafayette Plant. After giving a brief history of reciprocating engines and steam turbines, the speaker gave the history of the plant. Not many years ago, in 1906, the middle west conceived the idea of interurban roads. To accomplish this, it was necessary to combine a number of city street car systems and to build connecting lines from city to city, touching as many small towns as possible and obtaining local passenger and freight traffic. Upon combining all the local systems, it fell to the lot of the engineer to use the engines, turbines, boilers, and other auxiliary apparatus found in the several power houses and to concentrate the best in one central station. The Lafayette station under the above conditions contains a representative of all makes and kinds of apparatus. In its day it would have been pointed out as a modern and up-to-date station.

In the plant, the coal is handled directly over storage bins on an elevated track and unloaded from dump bottom cars. It is then taken from the storage bins through an underground tunnel in which there is a narrow gauge track into a small coal car and transported by steam elevator to overhead bunkers, which are connected to hoppers in front of the boilers by down spouts that feed the coal to chain grate stokers.

The boiler room consists of two 500 h.p. boilers and four 350 h.p. boilers giving in all approximately 2500 h.p. nominal rating.

The principal driving units consist of the following: one cross-compound engine direct connected to 500 kw., 3 phase, 380 volt, 25 cycle generator; one tandem compound engine direct connected to 500 kw., 3 phase, 380 volt, 25 cycle generator; one 400 kw., 3 phase, 380 volt, 1500 r.p.m. Westinghouse Impact Reaction Turbine; one 500 kw., 2 phase, 2200 volt, 60 cycle, 3600 r.p.m. Westinghouse-Parsons turbine. Three of these units are equipped with barometric condensers and the other, the cross-compound, with a surface condenser. The condenser pumps are long stroke, slow speed.

To make a comparison of these particular units, that is, a small turbine in its infancy, with Corliss engines that have for a number of years been up to their greatest efficiency would not be fair. The engines have been giving the best efficiency. Operating at full load, 26 in. vacuum 150 lb. gauge pressure, no superheat, the 500 kw. turbine used 22.6 lb. of steam per kw.-hr. and the 400 kw. turbine, 26.5 lb. On

the other hand, the cross-compound, operating under similar conditions except that steam contained 2 per cent moisture, used 14.3 lb. of steam per i.h.p. and the tandem compound 13.5 lb.

UNIVERSITY OF CINCINNATI

At a meeting of the University of Cincinnati Student Branch on April 9, Mr. L. C. Morrow of the Lodge and Shipley Company gave a talk on Time Setting in a Car Shop. Mr. Morrow pointed out that the conditions which prevail in a car shop differ greatly from those of other manufacturing plants. The machines are more easily operated, the work is rougher, and the employees are for the most part unskilled. Also the weather and the seasons of the year affect the car shop men. The shops are practically open, and, in the winter, the lubricating oil freezes and other elements of like nature cause delay. The main fact, however, that the weather is cold causes the men to work steadily, and perhaps harder than in summer.

In setting the time for a particular job, the operations are broken down to their elementary movements. For example, if the operation was one of a small punch press, the movements would be something like this: Take from pile to machine, place in position, press the foot pedal, remove the work and place on finished pile. The individual movements would then be timed by means of a stop watch. With this data in hand, the final time limit would depend on such variables as number of pieces, importance of operation, materials used, interruptions by foremen or others and time for lunch. Then having taken the above into consideration, it is wise to allow a sufficient margin, which, in most cases, is 20 per cent. The speaker showed that in some kinds of work considerable time must be allowed for recuperation. Mr. Morrow concluded his talk by discussing the attitude of the employee towards the time setter. He also gave some suggestions as to the best method of getting results, and related some of his experiences.

UNIVERSITY OF COLORADO

A meeting of the University of Colorado Student Branch was held on April 22, at which Charles W. Comstock, former state engineer, spoke on The Engineer in the Business World. During the talk, he pointed out what an engineer is or should be and advocated more thorough courses in English, history, political economy and logic in addition to the technical subjects and in place of the so called practical work, a large part of which might much better be left to be obtained outside of school. The need of preparation for the strictly "business side" of an engineer was further emphasized by the statement that engineering plans are often vetoed by boards of directors not because of some error in design or estimate, but because of the poor business aspect as seen by men in the commercial world.

UNIVERSITY OF MINNESOTA

An open meeting of the University of Minnesota Student Branch was held on April 15. A set of five films showed very completely the important and interesting features of the manufacture of Maxwell Motor Cars. They began with the reduction of the iron from the ore and passed through the manufacture and testing methods to the shipment and selling of the cars. The series was concluded with a tour through some very beautiful mountain country, during which the car was made successfully to mount some very steep grades.

UNIVERSITY OF MISSOURI

A meeting of the University of Missouri Student Branch was held on April 22. Prof. A. L. Westcott read a paper on Boiler Practice in St. Louis. The paper was largely an account of many tests performed by the author in the service of St. Louis Water Works system, which consists of three high service stations and one low service station. The purpose of the various tests was the reduction of the coal consumption, which was about 60,000 tons per year.

The Hawley down draft hand-fired furnace is very popular there, as it is more nearly smokeless than any other hand fired furnace. The boilers at the Baden Station were equipped with steam flow meters to determine the rate of evaporation. It was found that the rate of evaporation varied very greatly. This was due to the poor use, or rather non-control of the draft by the furnace. The non use of draft control by the furnace is due largely to the fact that dampers are unhandily arranged with respect to the firing floor. Shaft gauges and CO_2 recorders were installed so that readings could be taken from various parts of the furnace. Besides being valuable for determining conditions of combustion, the recorders are very useful in detecting air losses in furnace settings. In some old furnaces, these air losses reach 120 per cent. The method of detecting these "air leaks" with a CO_2 recorder is simple. The per cent of CO_2 is read as gases leave the boiler and also as they leave the furnace. The change in per cent of CO_2 shows how much air has leaked in through the setting. The best remedy for these air leaks is a sheet metal covering over the entire setting.

Poor boiler efficiency is due to excess air more than any other one thing. Excess air is due to fires of uneven thickness and its coming through thin spots in fire; also to holes in the fuel bed which allow larger quanities of air to pass through. This may be due to lumpy coal—good boiler practice allows no large lumps to be fired; dirty fires, where there is an accumulation of clinkers and ash, as the clinkers shut off air and allow poor mixture of gases; and excessive draft. At all times the draft should be proportional to the thickness and density of fire.

UNIVERSITY OF WISCONSIN

At a meeting of the University of Wisconsin Student Branch on March 25, the following officers were elected: J. B. Wilkinson, president; F. T. Goes, vice-president; W. D. Harvey, treasurer, and G. C. Richardson, secretary.

At a meeting on April 8, S. I. Roth gave a paper on The Buckeyemobile.

On April 22, Fred T. Goes read a very interesting illustrated paper on the Gate City Precooling Company. This plant was installed in 1910 at San Bernardino, California. for the purpose of the precooling of freight cars before their journey to the east. The capacity of the plant is 150 cars per day. The precooled air is blown in at one end of the car from the precooler by a sirocco fan, and the warmer air is drawn from the other end of the car by another sirocco fan, thence into the precooler chamber, cooled and blown into the car, continuing this path until the car is cooled to a temperature of 40 deg. fahr. The incoming temperature is 8 deg. fahr., and the air which leaves the car is at a tempearture of 29 deg. fahr. As the suction pressure and inflowing pressure are equal, the middle of the car is kept at atmospheric pressure. The advantages are many, for the prehandling of goods to and from storage is avoided, and the time schedule between producer and market is shortened.

WASHINGTON UNIVERSITY

At a meeting of Washington University on April 21, R. H. Tait of the Tait-Nordmeyer Engineering Company gave a general talk on Refrigeration. The speaker discussed the different designs of compressors, spherical and flat cylinder heads, single and double acting. He described the troubles with packing and varying clearance caused by change in temperature in the compressor. The different systems of ice making and refrigeration were explained. Air machines, vacuum machines, semi-flooded, flooded and expansion ammonia systems, block ice, plate ice and can ice methods were dealt with.

The cost of ice plants is about $1000 per ton capacity for plants of 30-50 ton capacity. The cost increases for larger capacities and decreases somewhat for smaller. The St. Louis Refrigeration Company has the largest ammonia transmission system in the world. They make ice and sell refrigeration to various users throughout the city. In a test made recently in that company's plant by Washington University students, their output was found to be 18 lb. of ice per ton of coal used. The Anheuser-Busch Company of this city has the largest ice plant in the world for making block ice.

EMPLOYMENT BULLETIN

The Secretary considers it a special obligation and pleasant duty to be the medium of assisting members to secure positions, and is pleased to receive requests both for positions and for men. Copy for the Bulletin must be in hand before the 18th of the month.

POSITIONS AVAILABLE

The Society acts only as a "clearing house" in these matters and is not responsible where firms do not answer.
In sending applications stamps should be enclosed for forwarding.

0104 Young engineer for efficiency department of Indiana concern. Preferably young technical graduate, alert, teachable, practical, with good clear thinking head.

0106 Superintendent for plant employing about 150, in the manufacture of motors, transformers and auxiliary apparatus. Location, Canada.

0108 Head superintendent for large European concern, engaged in the manufacture of rubber shoes, technical and surgical articles, covering for rollers, tubes of all kinds, balls, toys and articles to be made of hard or other rubber, etc. Applicant must be thoroughly posted in this kind of manufacture. Foreman also wanted for these branches. Apply by letter. Name confidential.

0113 Designing draftsman, experienced on marine boilers, engines and boats. Good opening for young technical graduate. State age, experience in detail and salary expected.

0114 Shop engineer, with at least five or six years' experience in heavy and light forge work, structural, steam and electrical engineering and efficiency methods of handling material throughout the shop; also manufacture of wood and steel freight and passenger cars, electric cars and general work of similar character. Must combine practical shop knowledge with technical education; capable of handling costs and piece work, estimating, etc., with other duties. Location, Canada.

0119 Engineer with experience in testing of steam and electrical apparatus and in the operation of steam power plants. Location, Delaware.

0123 Man with four or five years' experience in designing and construction of electrical cranes, to act as draftsman and designer. Location, Canada.

0124 Works manager for plant devoted entirely to the manufacture of shrapnel shells, having approximately one hundred machine tools and, in addition, a large furnace capacity. Prefer man with experience in this line, with ability to organize quickly a new force of several hundred men. Must be well versed in machining, heat treating and furnace methods. Name strictly confidential. Apply by letter.

0129 Chief draftsman for manufacturing plant in Philadelphia. State experience, references, salary, etc.

0130 Large concern in middle west making lubricators, valves, heating specialties, carburetors, etc., desires a technical graduate with three to five years' experience, competent to follow the entire products of the company through their evolution, design and manufacture. Applicant would be required to supervise and coördinate the work of the various departments. Complete experience in this line of manufacture is not necessary, but knowledge of mill construction and maintenance would be useful. Salary depends upon qualifications.

0134 Professor of mechanical engineering. Applications will be received to July first. Prefer man of Canadian birth. Salary, $2500; session seven months. Location, Canada.

0135 Young mechanical engineer wanted who has had an excellent technical training and a year or so of good practical experience; of good character and ability; or recent graduate willing to start at low salary. Apply through Society. Location, Massachusetts.

0136 Good opportunity for first class designer; a man with chiefly drawing office experience is needed, particularly on heavy machine tools and similar machinery. Location, Pennsylvania.

0139 Machine shop foreman for engineers, founders, machinists, manufacturing sheet and structural steel, elevating and conveying machinery and ice tools. The position pays fifty cents an hour for an eight or ten hour day. New York State.

0140 Engineer or designer and draftsman in the hydraulic press line. Man experienced in hydraulics capable of making designs and drawings for special presses such as veneer, binder board, hot plate presses, etc. Location, Pennsylvania.

0143 Chemist with two or three years experience in research and industrial chemistry; for position dealing particularly along line of paints, enamels, metal coatings and work of similar character. Location, New York.

MEN AVAILABLE

The published notices of "men available" are made up from members of the Society. Notices are not repeated except upon special request. Names and records are kept on the office list three months, and if desired must be renewed at the end of such period.

F-123 Industrial engineer with broad experience as consulting engineer and efficiency expert in machine shops, foundries, paper mills, etc., desires position as general manager or works manager. Would be interested in position where results would lead to business opening in firm.

F-124 Member, age 35, graduate M.E., Lehigh University, 14 years engineering experience in work requiring executive ability and tact in handling men, well qualified by training and experience to manage concern requiring broad engineering knowledge, mechanical, electrical and mining, and also ability to organize. At present engaged as general manager of coal mining company abroad. Is planning trip to Panama Fair in June or July, and can arrange interview en route from New York to San Francisco.

F-125 Junior member, mechanical graduate 1907, experienced in advertising and publication work, is open for position as publicity agent or advertising manager. Moderate salary at beginning if position is desirable otherwise.

F-126 Member, A.S.M.E. and Institution of Mechanical Engineers, with wide experience in all technical and commercial work, and in the American, European and Japanese markets, 16 years with exporters and importers of machinery, in charge of technical department in London and Tokyo, desires responsible situation in similar capacity. Familiar with English, German, French correspondence, and some Spanish.

F-127 Member, specializing in the installation of scientific management, expects to be at liberty from June first to December first, and desires engagements in this line during that time. Speaks Spanish fluently, and would accept engagements in Latin America for the investigation of the efficiency and possibilities of improvement of enterprises, or would undertake betterment work. If it should be desired that any temporary appointment become permanent, that could be arranged.

F-128 Associate-Member, graduate M.E., three years teaching and two of practical experience as assistant superintendent of small factory, has executive ability and capable of handling men, understands efficiency and cost keeping methods, will consider teaching or practical opportunity; willing to start on low salary in position of opportunity.

F-129 Junior member, graduate M.E., University of Wisconsin, five years experience in gasolene and kerosene, marine and farm engine design, including jigs, tools and special equipment. Engaged for six months at 750 kw. power plant, designing piping systems and general equipment. During last year and a half has been in charge of mechanical end of new cereal business. Will consider any good opening which may lead to executive position. Location immaterial.

F-130 Associate-Member, graduate M.E., Lehigh University, age 30, married, seven years experience designing, inspecting, erecting, selling and superintending in steam turbines, steel, pumps and waterworks specialties, desires responsible position where good character, personality, ability and application are assets.

F-131 Author of paper at Buffalo meeting desires responsible position; interview can be arranged there.

F-132 Associate-Member, age 32, with successful sales record, desires to become associated as sales engineer with manufacturer, preferably in the Middle West, or will open office as sales representative on commission if reasonable guarantees are made. Wide acquaintance with Chicago architects and engineers. At present employed.

F-133 Member, Stevens graduate, many years practical and teaching experience, desires position as professor of mechanical engineering. At present head of department in state college.

F-134 Junior, graduate M.E., Lehigh University, several years experience as draftsman, chief engineer's assistant, foreman and manager, at present located in prominent technical institution in New York, desires summer position which would afford experience in the mechanical field. Salary and location immaterial.

F-135 Mechanical and electrical engineer, 14 years varied experience with leading concerns in the design, manufacture, operation and maintenance of gas engines, oil engines and gas producers, testing and experimental work. Familiar with the construction and operation of large gas and steam electric power plants, pumping station, etc. Good organizer with executive ability and successful in handling men, desires responsible position with manufacturing concern or as chief engineer or general superintendent of large power system for the production and distribution of power.

F-136 Student member, age 23, graduate M.E., 1915, University of Minnesota, three months experience as draftsman in heating, ventilating and power design, desires position which offers opportunity for advancement.

F-137 Manufacturing superintendent familiar with the most efficient methods in machine shop, press work and assembling; good organizer and thorough systematizer, who can turn out production on schedule time, desires position. At present in automobile line.

F-138 Railway mechanical engineer, technical graduate with 16 years railroad experience as machinist, motive power draftsman and mechanical engineer, desires similar position, or one as mechanical inspector, assistant superintendent motive power or motive power assistant to general manager. Location immaterial.

F-139 Member, technical graduate, age 37, ten years wide experience in designing, engineering, production and accounting lines in manufacturing steam, gasolene and automobile engines and light and heavy machinery; also two years consulting and betterment work in factories handling similar products. Would negotiate with engineers and accountants. Location Middle West, preferably Detroit.

F-140 Mechanical engineer with broad experience in design and construction of water tube boilers and general plate work, also designing, estimating, purchasing and assistant manager, energetic and good organizer, desires responsible position with growing concern in Middle West.

F-141 Graduate M.E., four years manufacturing and designing experience, will leave present position to obtain sales training. Salary secondary.

F-142 Associate-Member, 13 years experience in operating and superintending power plants. At present holding responsible position as chief engineer of several plants, desires similar position with greater opportunity for advancement.

F-143 Mechanical engineer with 11 years experience in shop, office and field, desires to improve his conditions.

F-144 Member, age 42, graduate of Stevens Institute of Technology, 1893, with 15 years general experience, from draftsman up through executive management, followed by seven years specializing in organization and efficiency work in both manufacturing and commercial ends in a wide variety of lines, including machine shop, manufacture of chocolate, underwear, wholesale news distribution, brass goods, foundry, paper boxes, printing and publishing, desires a permanent connection with a progressive concern, location preferred, New York or vicinity. Will invest if conditions are favorable.

F-145 Junior member, age 27, Stevens graduate, class of 1911, possesses initiative and unusual mathematical ability, with four years experience in experimental, plant and executive work, desires change. Employed in Middle West, but coming to New York about July 10th.

F-146 Mechanical engineer, age 26, unmarried, graduate of middle western university, several years experience in field and office, is open for position, preferably in construction work. Location immaterial.

F-147 Mechanical engineer, age 30, married, technically educated, 12 years practical experience with large concerns as chief draftsman, and mechanic for valves, engineering specialties, tools, automobile and special machinery, mechanical write-ups, power plant design, installations and experimenting.

F-148 Associate-Member, age 31, technical education, journeyman machinist, first class draftsman, ten years experience in shop, drawing room, testing and designing tools for manufacturing of small interchangeable parts, wants to get into similar line. Ability to handle men. Location immaterial; salary secondary to opportunity.

F-149 Sales engineer, age 30, married, wide acquaintance in the southeastern states, experienced in handling steam, gas, hydraulic and electrical equipment for largest builder in America, wishes to locate permanently in his native South in capacity of district manager, or sales agent for similar or allied lines. At present employed, but desires change for personal reasons.

F-150 Member, Cornell graduate, age 38, married, nine and one half years experience in railroad shop, testing laboratory, drafting, supervision of power plant and foreman; two years construction work, design and installation of equipment in steel mills, desires position in mechanical department of railroad, manufacturing concern or firm of engineers.

F-151 Member, age 34, technical education, married, with broad experience with leading engineers in the East on design of steam power plants, heating and fire protection systems and inspection of mill and power plant construction and equipment, desires position with large manufacturing concern; at present employed as superintendent of construction on large mill and power plant.

F-152 Technical graduate, three years experience in construction work and repair, desires to get in touch with a master mechanic or chief engineer of large industrial plant or power company. Ability to handle men. At present employed.

F-153 Associate-Member, M.E. Case School of Applied Science, age 32, married, four years experience in engineering sales work, two years designing and installation of heating and ventilating equipment for industrial plants; has travelled in Cuba and South America, desires position with manufacturing or engineering concern. Will consider very reasonable salary till ability is proven. Location middle west, preferred, but will go elsewhere for real opportunity.

F-154 Student member, 1914, M.E., graduate of Lehigh University, some machine shop and foundry experience; at

present employed as instructor of mechanical drawing, desires position.

F-155 Member, technical graduate, age 32, having two capable associates and office centrally located in Philadelphia, solicits representation for reputable manufacturer who now has some trade in Philadelphia, but has at present no direct representation. The character of the product must be such that a considerable business will be possible as a result of thorough and systematic engineering salesmanship.

F-156 Member, age 33, married, Cornell graduate, 12 years experience in manufacturing, engineering and selling, desires executive position in small city involving little or no traveling. At present machinery sales manager in Chicago for large corporation. Present salary $300.

F-157 Member, graduate Massachusetts Institute of Technology, age 36, 12 years successful experience as works manager or superintendent; thoroughly practical as well as technical. Managerial experience includes foundries, pattern shops, machine shops, erecting, sheet-metal stamping, electro-plating, lacquering, lithographing, miscellaneous machinery, power plant management, plant construction and equipment. Familiar with modern factory, and has handled from 1000 to 1500 men, desires position as works manager or superintendent.

F-158 Junior member, 1914 graduate, desires a position with a company specializing in the design of manufacturing plants.

F-159 Member, 20 years valuable and complete experience in design and construction of printers and allied trades machinery, desires engineering or executive position where this experience will be of advantage. At present employed.

F-160 Junior, age 38, sales engineer, broad experience in handling high grade mechanical specialties, large acquaintance with mill supply and machinery trade, desires to represent manufacturer in East or Middle West in capacity of district sales manager.

F-161 Technical graduate, two years shop and testing and seven years experience in teaching mechanical engineering subjects, desires position in university or technical school.

F-162 Member, graduate M.E., married, experienced in the management of the power and mechanical departments of industrial plants, and the mechanical departments of railroads; also wide and varied experience in sales and purchasing. Capable of managing coal mining property or plant manufacturing machinery. Prefer representing manufacturers of railway supplies or heavy machinery.

F-163 Member, age 39, married, with broad and thorough manufacturing experience from apprentice to agency manager in a large engineering corporation manufacturing steam and producer gas engines, producers and transmission machinery; with firm for nine years in the capacity of draftsman, designer, estimator, mechanical engineer, salesman and agency manager, also experienced in efficiency engineering, correspondent and advertising, desires position.

F-164 Graduate of Stevens, age 32, chief engineer of firm of industrial engineers, now completing construction and equipment of large manufacturing plant in South, entirely capable of general supervision of such contracts, investigating and developing prospects, as well as of preparing plans and specifications and superintending construction of any type of building, with power generation and distribution, etc., seeks new engagement. Location and salary no difficulty.

F-165 Junior member, M.I.T. graduate, age 27, married, four and one half years experience, including drafting, power plant, textile machinery, office and executive work, desires permanent position with reliable concern offering chance for advancement.

F-166 Student member, technical graduate E.E. of cooperative course, University of Cincinnati, five years practical experience in large western ice-machine and electric company. Experience embraces jig and fixture design, analysis of production costs, estimating, d.c. electric design and practical machine shop work, desires employment with engineering or manufacturing company, preferably as assistant to works manager or superintendent. At present employed. Salary secondary consideration.

F-167 Technical graduate in mechanical engineering, age 26, two years experience as mechanical draftsman in the designing and planning department of the Panama Canal, thoroughly familiar with railway equipment, dredging and excavating machinery, desires outdoor position with irrigation or power development company. Location preferred Pacific Coast or Rocky Mountain states. Present salary $1500.

F-168 Member wishes to arrange for the manufacture and marketing of an improved type of shop appliance for which there is a constantly increasing demand at a good profit.

F-169 Junior member, technical graduate, married, traffic engineer of large company manufacturing motor trucks, desires similar position with one of the best makers of trucks, located either in Buffalo, Cleveland or Detroit. By coordinating the efforts of sales manager, assistant manager and traffic engineer, the effective results of dealer, branch house or traveling salesman can be materially increased and a plan for effecting the installation of motor trucks where horses are now used, or for increasing sales, can be realized.

ACCESSIONS TO THE LIBRARY

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A.I.E.E. and A.I.M.E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION. Proceedings of 24th Annual Convention, 1914. *Chicago, 1914.* Gift of Association.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS. Eighth Annual Report, 1914. *Madison, 1914.* Gift of Society.

APPRAISAL OF PUBLIC UTILITY PROPERTIES. Wm. G. Woolfolk. Read before the 7th Annual Convention Indiana Gas Association, March 10, 1915. Gift of Messrs. Sanderson & Porter.

ATLANTIC DEEPER WATERWAYS ASSOCIATION. Proceedings 7th Annual Convention, Sept. 22-26, 1914. *Philadelphia, 1915.* Gift of Association.

BOSTON TRANSIT COMMISSION. Twentieth Annual Report, 1914. *Boston, 1914.* Gift of Boston Transit Commission.

CONNECTICUT. BUREAU OF LABOR. Twenty-sixth Report, 1914. *Hartford, 1914.* Gift of Connecticut Bureau of Labor.

ON THE EARTHQUAKES OF 1868 IN HAWAII. H. O. Wood. Reprinted from The Bulletin of the Seismological Society of America, Dec., 1914. Gift of C. W. Rice

GREAT BRITAIN. Patent Office. Key to the classifications of the Patent specifications of France, Germany, Austria, Netherlands, Norway, Denmark, Sweden and Switzerland. Ed. 3. *London, 1915.* Gift of Patent Office.

INDUSTRIAL DIRECTORY OF NEW YORK STATE. Second Annual, 1913. *Albany, 1915.* Gift of New York State Department of Labor.

INSTITUTION OF MECHANICAL ENGINEERS. Address by the President, W. C. Unwin, April 16, 1915. Gift of author.

LELAND STANFORD JUNIOR UNIVERSITY. Register 1914-1915. *Stanford University, 1915.* Gift of A. S. M. E.

NEW ENGLAND, and ten years of the New Haven Road, address to the members of the Eastern Connecticut Development Committee and of the Civic Associations of Norwich, New London, Willimantic, Putnam and Danielson, Howard Elliott, Apr. 8, 1915. Gift of Bureau of Railway Economics.

NEW YORK CENTRAL & HUDSON RIVER RAILROAD COMPANY.

Report of the Board of Directors to the Stockholders, Dec. 31, 1914. *New York, 1914.* Gift of Company.

NEW YORK CITY. BUREAU OF BUILDINGS. Report, Dec. 31, 1913. *New York, 1913.* Gift of Bureau of Buildings.

PITTSBURGH. BUREAU OF WATER. Annual Report, 1913. Gift of Bureau of Water.

PUBLIC INTEREST IN TRANSPORTATION. An address at the Annual Dinner of the Traffic Club of Chicago, Feb. 1915, by Wm. Sproule. Gift of Bureau of Railway Economics.

PUBLIC REGULATION OF RAILWAY WAGES, F. H. Dixon. Gift of Bureau of Railway Economics.

RAILROADS AND THE PUBLIC. An address by Daniel Willard, March 22, 1915. Gift of Bureau of Railway Economics.

SOCIETY OF CONSTRUCTION OF FEDERAL BUILDINGS. List of Members, 1915. Gift of Society.

SOUND STEEL INGOTS AND RAILS, Sir Robert A. Hadfield and Geo. K. Burgess. Paper to be read before Iron & Steel Institute, Annual meeting 1915. Gift of Sir Robert A. Hadfield.

TRANSPORTATION OF GASES, LIQUIDS AND SOLIDS BY MEANS OF STEAM, COMPRESSED AIR AND PRESSURE WATER, Oskar Nagel. *New York, 1909.* Gift of Hunt Memorial Fund.

U. S. STANDARD SCHEDULE OF FLANGED FITTINGS AND FLANGES, 1915. Chart. Gift of National Association of Master Steam and Hot Water Fitters.

UNIVERSITY OF ILLINOIS. Alumni Record. *Urbana, 1913.* Gift of A. S. M. E.

ZURICH. Technischen Hochschule. XLV. Adressverzeichnis der Mitglieder der Gesellschaft ehemaliger Studierender der Eidgenössischen technischen Hochschule in Zurich. 1914. *Zurich, 1914.* Gift.

EXCHANGES

AMERICAN BUREAU OF SHIPPING. Record of American and Foreign Shiping, 1915. *New York, 1915.*
——— Rules for Building and Classing Vessels.

AMERICAN GAS INSTITUTE. Proceedings, vol. IX, pts. 1-2, *1914.*

BUREAU OF RAILWAY ECONOMICS. Statistics of Railways, 1903-1913, United States. *Washington, 1915.*

INSTITUTION OF CIVIL ENGINEERS, MINUTES OF PROCEEDINGS, vol. 198. *London, 1915.*

KONINKLIJK INSTITUUT VAN INGENIEURS. Register 1913 's-Gravenhage, 1915.
——— Naamlijst der leden, 1915.

TRADE CATALOGUES

ASBESTOS PROTECTED METAL CO., *Pittsburgh, Pa.* Bulletin 55. Asbestos Protected Metal for roofing and siding. (Designed and written by Ray D. Lillibridge, Inc.)

BECKER MILLING MACHINE CO. *Hyde Park, Mass.* Becker continuous millers. Models SB, CS and SD.

CHAMPION RIVET CO. *Cleveland, Ohio.* Scientific facts. Ed. 4. 1914.

CLARK BROS. CO. *Olean, N. Y.* Catalogue of saw mill machinery, 200 pp.

COATESVILLE BOILER WORKS. *Coatesville, Pa.* Bull. 17. Steel plate construction.

CRANE COMPANY. *Chicago, Ill.* Complete pocket catalogue No. 40. Sept., 1914.

FAFNIR BEARING CO., *New Britain, Conn.* Catalog No. 15. Fafnir ball bearings.

FLANNERY BOLT CO., *Pittsburgh, Pa.* Staybolts, March 1915.

GAS ENGINE & POWER CO. AND CHAS. L. SEABURY & CO. *New York City.* Catalog No. 10. Seabury safety water tube boilers.

INTERNATIONAL MOTOR COMPANY. *New York City.* Mack truck specifications 1 and 2-ton worm drive.

JOHNS-MANVILLE CO., *New York, N. Y.* Catalog 252. J-M Railroad supplies.

LESCHEN, A. & SONS, ROPE CO., *St. Louis, Mo.* Leschen's Hercules, March, April 1915.

STEPHENS-ADAMSON MFG. CO., *Aurora, Ill.* Labor saver, March 1915.

UNDER-FEED STOKER CO. OF AMERICA, *Chicago, Ill.* Publicity Magazine, March 1915.

WALWORTH MFG. *Co., Boston, Mass.* Walworth Log, March 1915.

UNITED ENGINEERING SOCIETY

AËRIAL NAVIGATION, A. F. Zahm. *New York, 1911.*

ALLIAGES ET FONDERIE DE BRONZE, Victor Marteil. *Paris, 1910.*

AMERICAN MANUFACTURERS EXPORT ASSOCIATION. Year Book, 1914. *New York, 1914.* Gift of Association.

ANTHRACITE COAL COMBINATION IN THE UNITED STATES, Eliot Jones. *Cambridge, 1914.*

APPLIED MECHANICS, G. Lanza. Ed. 9. *New York, 1910.*

THE BELLS OF LYNN, C. J. H. Woodbury. Paper given before the Lynn Historical Society, Dec. 10, 1914. *Lynn, 1915.* Gift of author.

BETON KALENDER TASCHENBUCH FÜR DEN BETON UND EISENBETONBAU, X. Jahrgang, 1915, pts. 1-2. *Berlin, 1914.*

BIBLIOGRAPHIE DER DEUTSCHEN ZEITSCHRIFTEN LITERATUR. Band XXXIV, 1914. *Leipzig, 1914.*

BIBLIOGRAPHIE DER DEUTSCHEN ZEITSCHRIFTEN LITERATUR. Ergänzungs Band VII. Band XXXV A. *Leipzig, 1914.*

BIOGRAPHICAL DIRECTORY OF THE RAILWAY OFFICIALS OF AMERICA. 1913 edition. *New York, 1913.*

BROWN'S DIRECTORY OF AMERICAN GAS COMPANIES, 1914. *New York, 1914.*

CALCUL GRAPHIQUE ET NOMOGRAPHIE, M. d'Ocagne. *Paris, 1914.*

CALCULUS AND ITS APPLICATIONS, R. G. Blaine. *New York, 1914.*

CANADIAN MINING MANUAL, 1914. *Toronto, 1914.*

CARILLONS OF BELGIUM AND HOLLAND, W. G. Rice. *New York, 1915.*

CASES ON PUBLIC SERVICE COMPANIES, Bruce Wyman. Ed. 2. *Cambridge, 1909.*

CELLULOID, ITS MANUFACTURE, APPLICATIONS AND SUBSTITUTES, Masselon, Roberts and Cillard. *London, 1912.*

CELLULOSE, Cross & Bevan. *London, 1910.*

CENTRIFUGAL PUMPS, R. L. Daugherty. *New York, 1915.*

DIE CHEMIE DER HYDRAULISCHEN BINDEMITTEL, Hans Kühl und Walter Knothe. *Leipzig, 1915.*

CHEMISTRY AND ITS BORDERLAND, A. W. Stewart. *London-New York, 1914.*

CHEMISTRY OF PIGMENTS, E. J. Parry and J. H. Coste. *London, 1902.*

CIVIL ENGINEERING SPECIFICATIONS AND CONTRACTS, R. I. D. Ashbridge. *Chicago, American Technical Society, 1914.* Gift of author.

The author has developed a logical system of preparing specifications, including typical specifications for railroad work, bridges, culverts, excavations, fills, tunnels, roadbeds, country roads, and city paving. Forms for proposals, agreement and contracts are discussed and illustrated. W. P. C.

COLLECTION OF PAPERS, written by Geo. F. Kunz. Gift of author.

COMMERCIAL PROBLEM IN BUILDINGS, C. C. Evers. *New York, 1914.*

CONCRETE ROADS AND PAVEMENTS, E. S. Hanson. *Chicago, 1914.*

CONTROL OF PUBLIC UTILITIES, W. M. Ivins and H. D. Mason. *New York, 1908.*

CUSHING'S MANUAL OF PARLIAMENTARY LAW AND PRACTICE. Revised and enlarged by C. K. Gaines. *Boston-New York, 1912.*

DIE DAMPFKESSEL, F. Tetzner. Ed. 3. *Berlin, 1907.*

DESIGN OF STEEL BRIDGES, THEORY AND PRACTICE FOR THE USE OF CIVIL ENGINEERS AND STUDENTS, F. C. Kunz. *New York, 1915.*

DIRECT ACTING STEAM PUMPS, F. F. Nickel. *New York, 1915.*

DISTILLATION OF ALCOHOL FROM FARM PRODUCTS, F. B. Wright. *Ed. 2. New York, 1913.*

DOCK AND HARBOUR ENGINEER'S REFERENCE BOOK, Brysson Cunningham. *London, 1914.*

ECONOMICS OF BUSINESS, N. A. Brisco. *New York, 1913.*

EFFICIENT COST KEEPING, E. St. Elmo Lewis. Ed. 3. *Detroit, Burroughs Adding Machine Co., 1914.* Gift of publisher.

One of a type of books of real value issued to advertise the uses of the machine made by this company, but only as an incident in a well-written and useful treatise on cost keeping. The work is a distinct contribution to the literature of efficiency in management. W. P. C.